NOV 25 1931

INSTRUMENTS

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(Reg. U. S. Pat. Off.)

Devoted to Measurement and Control Problems

Vol. 4. No. 11 Pittsburgh, Pa. November, 1931

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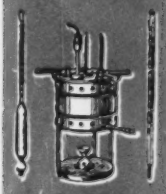

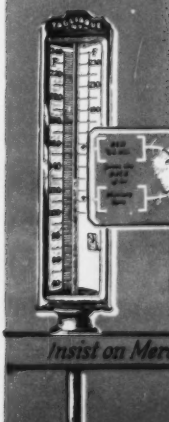

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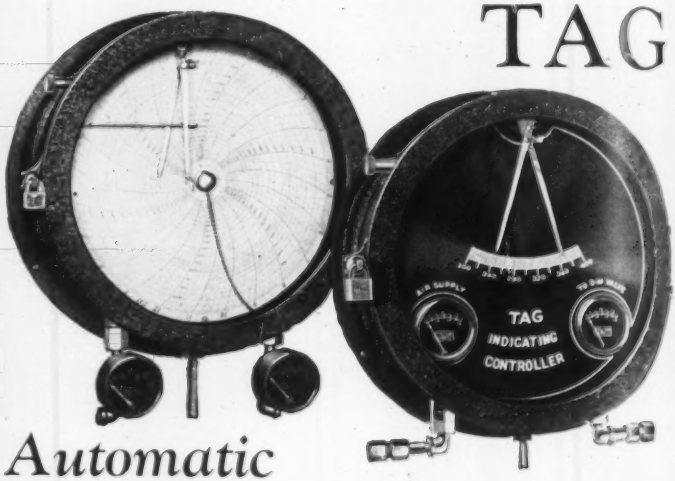

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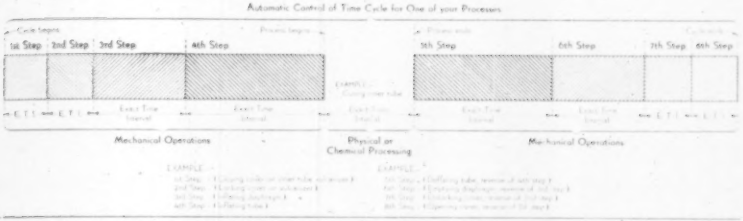

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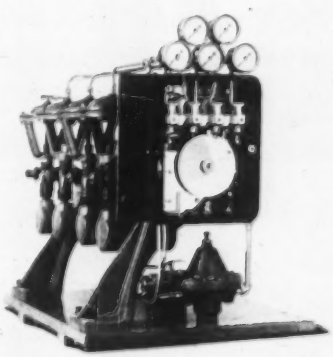

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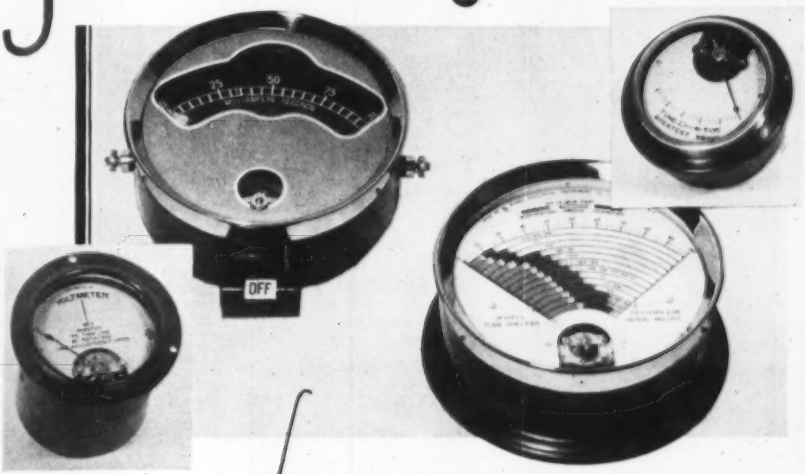

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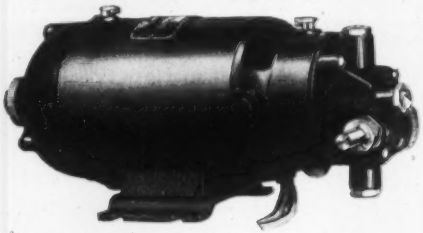

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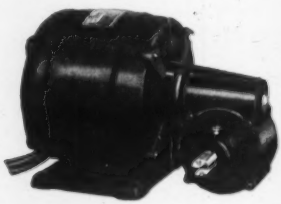

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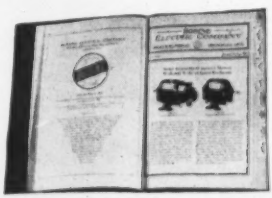

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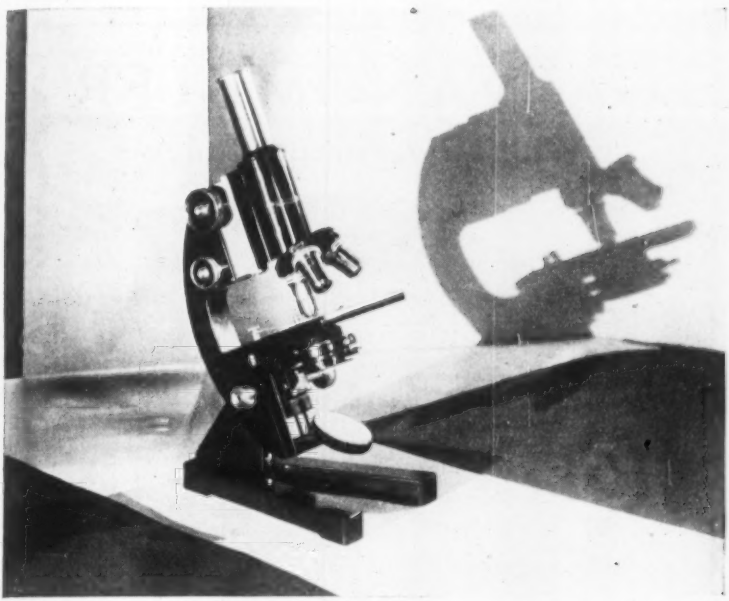

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Richard Rimbach, Managing Editor — **M. F. Béhar**, Engineering Editor

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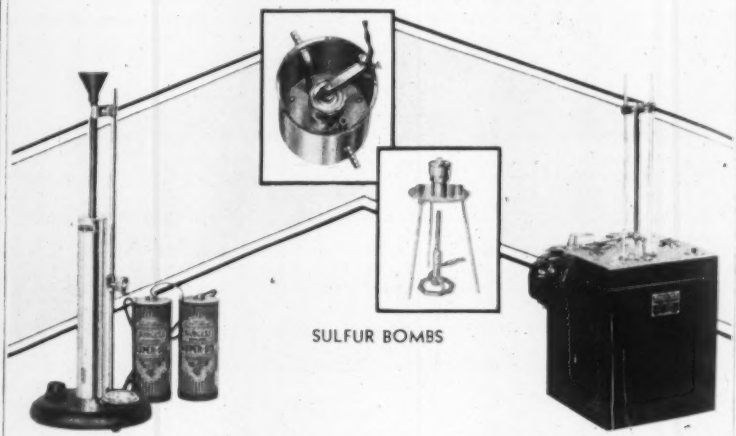

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EDITORIAL COMMENT

Two Great Lights are Extinguished

IN the short space of two days Death struck West Orange and Back Bay, depriving the world of two men whose achievements had largely contributed to its material progress and intellectual enlightenment.

Hardly had Samuel Wesley Stratton finished composing a beautiful eulogy to the memory of Thomas Alva Edison when he, too, breathed his last.

The entire world had joined Dr. Stratton in rendering tributes to its greatest inventive genius.

And many tender, affectionate expressions from the ranks of science, industry and education signalized the passing of the head of Massachusetts Institute of Technology, who had made the Bureau of Standards an essential part of modern industry.

To all these sorrowful tributes *Instruments* adds a modest lamentation — a mere word and halting, but heartfelt.

In the death of Edison we feel the loss of one from whose miraculously fertile brain sprang, among other devices closely related to Instrumentation, the first practical electricity meters; one moreover whose transformation of our civilized world was a great single factor giving rise to modern Instrumentation . . . To say more would be but weakly to echo far abler salutes.

And in the passing of Dr. Stratton we have lost a dear and understanding friend of all instrument makers and users. "Standard Bearer and Standard Maker" ran the inspired title of an editorial note in the *New York Times*. Indeed it is difficult to imagine the comparatively backward state in which the science of measurement would be had not this exponent of Exactitute built up the Bureau from a handful of men to 900 solvers of measurement problems in a dozen splendidly equipped buildings.

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PYROMETER MAN: Graduate Pennsylvania State College. Had charge of pyrometer calibration laboratory in plant with 1100 pyrometers. J-3.

METALLURGIST: 1½ years University of Pennsylvania; 7 years night school Carnegie Institute of Technology. 2 years steel plant analyst; 7½ years plant metallurgist in foundry. Can read German, Polish, Bohemian and Russian. J-4.

METALLURGIST: Graduate University of Pittsburgh; 5 years steel plant metallurgist; 6 years sales metallurgist; 3 years metallurgist automotive plant. J-5.

ELECTRICAL ENGINEER: Graduate Charlottenburg Technische Hochschule; 8 years research engineer with chemical company; 4 years steel plant electrical engineer; can read German, French, Spanish and Italian. J-6.

INSTRUMENT SALESMAN: Mechanical Engineering Graduate; experienced sales and service most type of power plant instruments. District Sales Manager 5 years. Experience on gages, flow meter, CO_2 recorders, pyrometers and other testing equipment. J-8.

PYROMETER MAN: 8 years experience; expert electrician and gage (hydraulic, pressure, vacuum, etc.) service man; 3 years instrument laboratory; education equivalent two years of engineering college. J-9.

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ELECTRICAL METER and INSTRUMENT MAN: Technical graduate, 8 years in Instrument Laboratory of Electrical Manufacturing Company. J-17

INSTRUMENT ENGINEER: 2 years university, 5 years public utility, 2 years sales and service large recording and controlling instrument manufacturer. J-18

INSTRUMENT MAKER: Engineering and Drafting instruments, 20 years shop experience, Master Degree Guild of Nuremburg. J-19

ELECTRICAL ENGINEER: Graduate Purdue University. Experience with Telephone and Telegraph circuits, industrial control methods and equipment, and electrical instrument testing and maintenance. J-20

Ohmer Fare Register Company has announced the appointment of Mr. J. B. Wallis as manager of its Eastern District with headquarters in the Ohmer Building at 146 West 63rd Street, New York City. Prior to his becoming associated with the Ohmer Company, Mr. Wallis was Southeastern District Sales Manager for the Remington Cash Register Company.

THE HANDBOOK OF INDUSTRIAL INSTRUMENTS

M. F. Béhar*

CHAPTER XV

Speed and Acceleration

(*Continued*)

22. Stroboscopes

(a) Principles

When a mechanism in rapid rotating, reciprocating, oscillating or vibratory motion is glimpsed momentarily once each cycle at a given point in the cycle, it appears to stand still because the impression made on the retina of the eye at each glimpse is retained during the brief interval until the next glimpse.

A disk rotating at f revolutions per second and viewed with a glimpse frequency of f c.p.s. (once each revolution) appears to stand still. Suppose it to be a black disk with a chalk mark drawn as a straight radial line. If the glimpse frequency is f/b c.p.s. (b being an integer) it appears to stand still because it is viewed every b revolutions and the mark is seen in the same place at each glimpse. If however the glimpse frequency is $2f$ c.p.s. the disk is viewed twice per revolution and the eye sees two marks 180° apart—a diameter instead of a radius—which pattern appears to be stationary. The same pattern shows when the frequency is $2\ f/b$ c.p.s. With a glimpse frequency of $3\ f$ c.p.s. (or $3\ f/b$ c.p.s.) the disk is viewed three times per revolution and the eye sees three stationary marks 120° apart. With a glimpse frequency of $4\ f$ c.p.s. (or $4\ f/b$ c.p.s.) the appearance is that of a stationary cross.

With a glimpse frequency of af c.p.s. or af/b c.p.s. (a being an integer) the appearance is that of a stationary wheel of a spokes.

Similarly, a wheel having n spokes and viewed n times per revolution appears to stand still; and if viewed na times per revolution it appears to have na spokes. If viewed n/b times per revolution it appears as a stationary wheel of n spokes and if viewed na/b times per revolution it appears to have na spokes—the pattern always appearing stationary in all four cases. In other words, if a wheel of n spokes rotates at f revolutions per second and if the glimpse frequency is $f \times (na/b)$ it will appear as a stationary wheel of na spokes.

But if the glimpse frequency differs from $f \times (na/b)$ by $1/b$ c.p.s., the eye will see a wheel of na spokes which appears to rotate at $1/na$ revolutions per second, that is, at the rate of one apparent spoke per second, whatever the number n of spokes on the actual wheel.

These relations make it possible to *measure* (1) speeds of rapidly rotating shafts, (2) rapid frequencies of mechanisms—both with the aid of known glimpse frequencies; and, conversely, (3) commercial, audio and certain other frequencies, with the aid of disks rotating at known speeds viewed by the

*Engineering Editor

intermittent light of lamps flashing at the frequencies to be measured. These three classes of speed and frequency measurements are known as stroboscopic* methods.

Stroboscopes, however, are generally instruments using controllable glimpse frequencies and used (1) for the slow-motion study of the *effects* of "strobic" (rapidly rotating), oscillating, reciprocating or vibrating motion, and (2) for the measurement of speed or frequency. We are only concerned here with the latter use, which requires that the glimpse frequency be not only controllable but *known*—preferably *indicated*.

(b) Types of Stroboscopes

Stroboscopes may be divided into those that interrupt the line of sight from the observer's eye to the (constantly illuminated) object, and those which provide intermittent illumination whether by means of intermittent light source or interrupted light. Again, they may be divided into two types, the "glow" (intermittent light source only) and the "slit" (comprising both interrupted illumination and interrupted line of sight). It seems best to recognize three distinct types employed for speed measurement:

(1) *Interrupted Line of Sight*—Instruments consisting essentially of a rapidly moving slotted arrangement or other suitable device held in front of the eyes, whereby the object, which is illuminated by daylight or any other continuous source, is viewed intermittently at a known glimpse frequency.

(2) *Interrupted Light*—Instruments consisting essentially of a source of continuous light between which and the observed object there is interposed either a rapidly moving slot arrangement or a rotating mirror arrangement whereby the object is illuminated by extremely brief flashes of known frequency.

(3) *Intermittent Light Source*—Instruments consisting essentially of an electric light flashing at a known frequency, generally a neon lamp biased so that it flashes only during a very small part of a half-cycle, controlled by a magnet-driven tuning-fork contactor, constant-speed motor-driven contactor, etc.

(c) Practical Considerations

To simplify the discussion we first assume a rapidly rotating black disk with one thin white radial chalk mark, the angular width of which is only 10 minutes of arc but which can nevertheless be seen plainly even in dim light.

If the duration of a glimpse corresponds to 1/360 of a *revolution*, the chalk mark will appear not as a line but as a wedge having a taper of 1°10′ or seven times its natural width. It will appear gray. Its definition will not be good. If the disk is rotating at 6000 r.p.m. (100 r.p.s.) and the glimpse characteristics (of whatever type of instrument is employed) are

$$f = 100 \text{ c.p.s.} \qquad \text{vision period} = 1\% \qquad \text{interruption} = 99\%$$

then the mark will seem to have a width of $3.6° + 10′ = 3°46′$ and it will be seen less plainly. Its definition will be poor.

According to Talbot's Law, "the average intensity of the light which reaches the eye through any stroboscope when the glimpses are of sufficient frequency to blend together into a continuous appearance bears the same ratio to its normal intensity value that the time of exposure does to the total

*From Greek roots for "whirling" and "see."

time. In other words, if the light is admitted to the eye and cut off very rapidly with long periods between glimpses, the period of darkness can be as much as 100 times that of the light period, in which case the average intensity becomes only one-hundredth of the normal intensity."*

The intensity of the light reflected from the disk as a whole is 1/100 by reason of the 1% vision period during one cycle; the broadening of the 10′ mark to a 3°46′ band (180 + 46 = 226′) cuts down this 0.01 intensity 22.6 times making it 0.00044.

If the glimpse characteristics are now changed so that the period of vision is 10% of a cycle, the intensity of whatever is viewed will be 10% of normal instead of 1% but the mark will now have an apparent width of 36°10′ (or 2170′) so that its visibility will be cut down by a factor of 217 on account of this broadening. Its effective intensity will be 0.00046, which is about the same as before.

It is plain to see that an unavoidable dilemma results from the conflict between definition and illumination or vision, and renders difficult the universal attainment of good results for a wide variety of observed objects by any one stroboscopic method. The interrupted light instruments require powerful sources of continuous light. The neon tubes must flash very brilliantly during extremely brief vision periods. Both these types are preferably used to observe mechanisms (or disks on measured shafts) *that are subjected to no other illumination.* The interrupted line of sight type of stroboscopes is free from this limitation but it cannot be used for objects under dim light. In all three types, ideal sharpness of definition is unattainable.

For most industrial measurements of rotational speed, however, sharpness of definition can be overlooked, by reason of the slow rotation effect mentioned in Art. (a) of this Section. In practice, a fine line is unnecessary. A big chalk mark can be made on the end of a shaft, roughly covering most of the area of a 30° sector. The glimpse frequency of the stroboscope is adjusted until this mark (plainly visible even under unfavorable conditions) gradually ceases to appear as a round blur and appears as either one mark or as a regular pattern. If there are too many "spokes" a further adjustment is made until the number can be counted without error. This pattern will appear to rotate and the governor of the instrument is given a last adjustment to make the mark or pattern slow down and finally seem stationary. Then, the glimpse frequency is read off on the indicator which either forms part of the stroboscope or comes as an accessory instrument, and from it the speed of the shaft is deduced. Some indicators are calibrated in glimpses per *minute* to facilitate expressing the measured speed in the customary r.p.m. of engineering.

(d) Stroboscopic Disks

For speed measurements there are also employed disks bearing regular patterns, whereby advantage is taken of the fact that a wheel of n spokes viewed n times per revolution appears to stand still, and of the other relations discussed in Art. (a). By means of these stroboscopic disks, speeds may be measured conveniently. These disks are readily attached to the ends of shafts, even on light machinery that would slow down if tachometers were held in contact, and their various ingenious patterns greatly increase the range of each instrument.

*"Some Notes on the Stroboscope." A. J. Ashdown, Ltd.

STATIONARY FIGURES FOR GLIMPSE FREQUENCY OF 50 PER SECOND

R.p.m.	APPEARANCE OF			
	Star	Hexagon	Pentagon	Square
350	Double	....	....	....
375	....	....	....	Double
400	Single	....	Triple	....
450	Double	....	....	....
500	Single	Single	....	Triple
550	Double	....	....	....
600	Single	....	Single	....
650	Double	....	....	....
666.7	....	Triple	....	....
700	Single	....	....	....
750	Double	Double	....	Single
800	Single	....	Triple	....
833.3	....	Triple	....	....
850	Double	....	....	....
900	Single	....	Double	....
950	Double	....	....	....
1000	Single	Single	Triple	Triple
1050	Double	....	....	....
1100	Single	....	....	....
1125	....	....	....	Double
1150	Double	....	....	....
1166.7	....	Triple	....	....
1200	Single	....	Single	....
1250	Double	Double	....	Triple
1300	Single	....	....	....
1333.3	....	Triple	....	....
1350	Double	....	....	....
1400	Single	....	Triple	....
1450	Double	....	....	....
1500	Single	Single	Double	Single
1550	Double	....	....	....
1600	Single	....	Triple	....
1650	Double	....	....	....
1666.7	....	Triple	....	....
1700	Single	....	....	....
1750	Double	Double	....	Triple
1800	Single	....	Single	....
1833.3	....	Triple	....	....
1850	Double	....	....	....
1875	....	....	....	Double
1900	Single	....	....	....
1950	Double	....	....	....
2000	Single	Single	Triple	Triple
2050	Double	....	....	....
2100	Single	....	Double	....
2150	Double	....	....	....
2166.7	....	Triple	....	....
2200	Single	....	Triple	....
2250	Double	Double	....	Single
2300	Single	....	....	....
2333.3	....	Triple	....	....
2350	Double	....	....	....
2400	Single	....	Single	....
2450	Double	....	....	....
2500	Single	Single	....	Triple
2625	....	....	....	Double
2700	Single	....	Double	....
2750	Double	Double	....	Triple
3000	Single	Single	Single	Single

Before describing two of these disks, mention may be made of a somewhat analogous method employed when the end of the shaft is not readily accessible. On the visible surface of the shaft a "spiral" (really a helix) is drawn of suitable uniform pitch or of purposely increasing pitch. A little practice prevents making mistakes in guessing when the glimpse frequency is twice, half, etc., the shaft speed: Two spirals are seen when the glimpse frequency is double and the shaft speed; and the spiral seen when the glimpse frequency is one-half the shaft speed is twice as broad as that viewed at equality.

Fig. 589 is reproduced from Diederichs & Andrae* and its upper left quarter shows the natural appearance of a twelve-point star disk, or as viewed when the disk speed is equal to, or twice, three times, etc., the

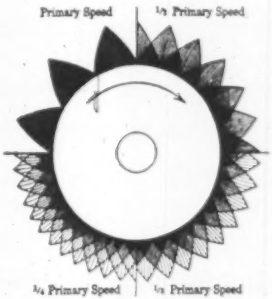


Fig. 589

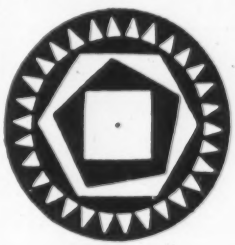


Fig. 590

glimpse frequency (which is denoted by "primary speed"). The other quarters show the apparent multiplying of the outer points in proportion to the glimpses per revolution. These multipliers may be determined by counting the "peaks" on the side of a "tooth."

Fig. 590 is reproduced from Griffiths† and shows a disk which gives a considerable number of figures, for glimpse frequencies equal to or related to disk speed by 2, 3, 4, 5, 6 and their multiples, the outer design being a thirty-point star. The accompanying table, while made up only for a glimpse frequency of 50 per second or 3000 per minute, can be used for other round-number frequencies with but little mental effort. This kind of disk, comprising a square, a pentagon and a hexagon in the 30-point design, is especially useful by reason of the *square*, since 4 is not evenly divisible in 30.

(e) Characteristics

Only those characteristics of stroboscopes of prime interest in connection with speed measurement are discussed.

The outstanding characteristic is that contact with the measured mechanism is unnecessary. Industrial stroboscopes are portable. Graphic records connot be obtained, nor are stroboscope used for automatic control. Measurement is indirect and discontinuous. There is no set duration for the measuring operation. Most of the instruments cannot be used for speed measurements by untrained personnel. Large errors may be made, as when deciding by what number to divide the glimpse frequency in order to obtain the speed.

*Experimental Mechanical Engineering, New York, 1930, Vol. I, page 64.
†Engineering Instruments and Meters, London, 1920, page 185.

Most industrial stroboscopes have to be connected to the electric circuit; some requiring transformers, etc. There are also, however, reliable spring driven models. Even hand-driven models are made.

The construction, in general, is typical of portable instruments not designed for continuous 24-hour service without maintenance attention.

Theoretically, there is no limit to the range over which the stroboscope can be used. Actually there are practical limits, which vary with the particular type, make and model.

Accuracy. The accuracy of a stroboscopic measurement of rotational speed—apart from guessing wrong as to the relation of glimpses to revolutions—depends entirely on the accuracy of the tachometer, tachoscope or speed indicator that indicates the glimpse frequency of mechanical vision-interrupting devices, or of the electrical frequency indicator in the case of an instrument employing an electrical intermittence method, or of the counter-and-timepiece method of measuring the speed of the slotted device in the case of other instruments.

The accuracy of individual stroboscopes depends, in addition, on the constancy with which any required glimpse frequency can be maintained. Not only will an instrument having a faulty governor make a uniformly rotating shaft appear to vary, but when the measured speed is fairly low, the difference between the glimpse frequency at which measurement is made and the glimpse frequency read off on the indicator a few seconds later may amount to a considerable percent error in the measured speed. When measuring high speeds, of course, faulty regulation of glimpse frequency is immediately noticeable but even then there is an element of uncertainty as to whether it is the shaft or the stroboscope that is erratic. Before placing a stroboscope in regular service, therefore, it is well to give it a simple test by viewing with it a Plant Standard (See Section 2) or any shaft known to rotate at absolutely constant speed; or an object known to vibrate at an absolutely constant frequency. An improvised tuning fork—a long spring steel tongue clamped in a vise—will do, provided only that someone with a keen sense of pitch is present to certify to its constancy at diminishing amplitudes. This recommendation does not apply to stroboscopes themselves designed and qualified to serve as Standards.

No statement can be made as to the comparative accuracy and general "figure of merit" of the three types, but it can and must be mentioned that of each general type there are some makes and models of excellent workmanship, fine precision and extreme accuracy, as well as models which are not suitable for speed measurements over a wide range. And since one of the reasons why a stroboscope is purchased for speed measurement is its wide range, such instruments possess smaller engineering usefulness. There are also models not designed for speed measurements at all.

Passing now from the three general types to sub-types or variants within each, it becomes not only possible but advisable to make certain statements as to comparative suitability. "Suitability," to narrow down its meaning, is that for (1) *convenient* measurements—not on a laboratory bench set-up but in, say, a power plant; and (2) *trustworthy* measurements, as in power test work. With these engineering requirements in mind, great differences become apparent:

Interrupted line of sight stroboscopes, for example, include disk instruments and cylindrical rotor instruments. These latter are represented by

binocular instruments of wide range, good accuracy, and design and construction suitable for engineering tests. The perforated disk instruments include scientific precision models which cannot conveniently be used in a plant, and some small light portable models designed primarily for motion study, which cannot measure speeds. Moreover, the rotating disks provide only monocular vision.

Interrupted light stroboscopes, likewise include tuning-fork instruments as well as several other models. Among these others are instruments eminently suitable for engineering test work. The tuning-fork stroboscopes

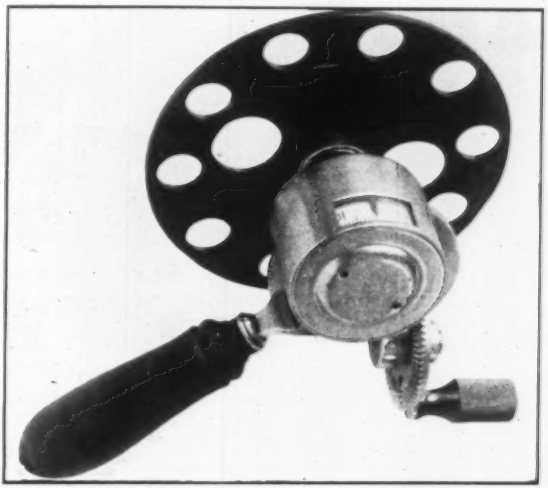


Fig. 591

are laboratory bench instruments—some of them of extreme accuracy but few of them made so that they can conveniently be taken out and set up for engineering test work.

It so happens that the most authoritative text on engineering tests declares under "stroboscopes" in the portion on "speed measurements"—

> The vision is interrupted by using either a tuning-fork arrangement or a rotating perforated disk driven by a separate machine.

The author believes it safe to assert, after canvassing the field,* that stroboscopes in which "the vision is interrupted by using either a tuning-fork arrangement or a perforated disk . . ." while available for certain kinds of scientific and commercial work, are not available for power test measurements of the speed of machinery.

(f) Interrupted Line of Sight Type

A simple rotating perforated disk stroboscope, Fig. 591, comprises a hand-driven centrifuge and a built-in continuously-indicating tachometer which can be read by the operator without changing his position or that of the instrument. To the tachometer spindle is attached a perforated disk giving ten glimpses per revolution, so that the speed of a chalk-marked shaft rotating at any speed up to ten times that of the tachometer can be measured. This instrument is designed especially for speed measurement, but the makers (a world-known American instrument firm) supply these stroboscopes for special purposes only, not for general sale, "due to their

*More than 300 instrument manufactuters, etc.

delicate nature and the trouble involved keeping them in repair." This candid statement, regarding one of the simplest of all commercial stroboscopes, throws much light on the question of the relative suitability of various classes and types of speed-measuring instruments for industrial plant service. The author is inclined to condemn not so much the interrupted line of sight type as the *perforated disk* sub-type of commercial stroboscopes, and not for the reason given by the makers of this one instrument but because in order to obtain a sufficiently high glimpse frequency, together with slots sufficiently large for sighting, the disks must not only rotate at high speed but be of impractically large diameter.

Pairs of slotted disks rotating in opposite directions are an improvement over the original single disk invented by Plateau about 100 years ago, but

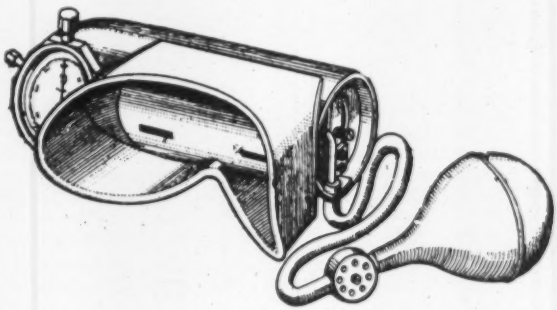


Fig. 592

even these paired disks cannot compare with the cylindrical rotors in practical service value. To give the same field, definition and lighting as the modern shutter arrangement shown in Fig. 597, the paired disks would have to have a diameter of five feet. And they would not give binocular vision.

"*Whidbourne*" (Baird & Tatlock, Ltd.) This English instrument, Fig. 592, dispenses with hand-crank, spring-motor and electric motor drives. It consists essentially of a rotating cylinder with a pair of slots along a chord, through which the moving object can be observed. A suitable hood for cutting off extraneous light is provided. The moving drum rotates on pivot bearings inside another fixed drum which has corresponding slots, so that when the four slots are in line an uninterrupted view of the moving object is obtained. The drum is driven by air pressure, produced by an ordinary small rubber bulb. When the required speed is obtained it can be maintained by a gentle pressure on the bulb, and the Haslar speed indicator shown on the left of the figure brought into operation. Speeds up to 4000 r.p.m. can be measured in this way. To measure greater speeds a drum having ten slots, which form a star-like pattern, is used. As, in this case, there are ten positions in which the fixed and rotating slots are in line for every revolution of the drum, the speed indicated will be one-tenth that of the object. The range of the instrument is 150-40,000 r.p.m.

The Rotoscope. This British instrument (A. J. Ashdown, Ltd., Livingston & Southard, U. S. agents) is being used successfully in a large number of American industrial establishments. It is made in two forms and various different models of which several are suitable for speed measurements. The self-contained form is shown in Figs. 593 and 594; the electrically driven

form is shown in Fig. 595. The diversity of models is obtained by providing different sight gears, different gear-shifting ratios, etc.

The self-contained form has its shutter driven by a clockwork said to provide better constancy of speed (and hence of glimpse frequency) than

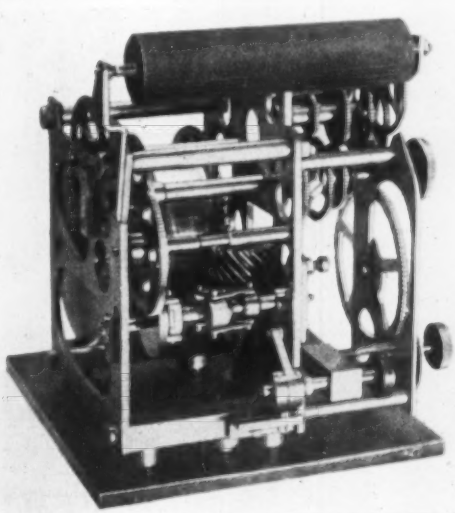


Fig. 593

Fig. 594

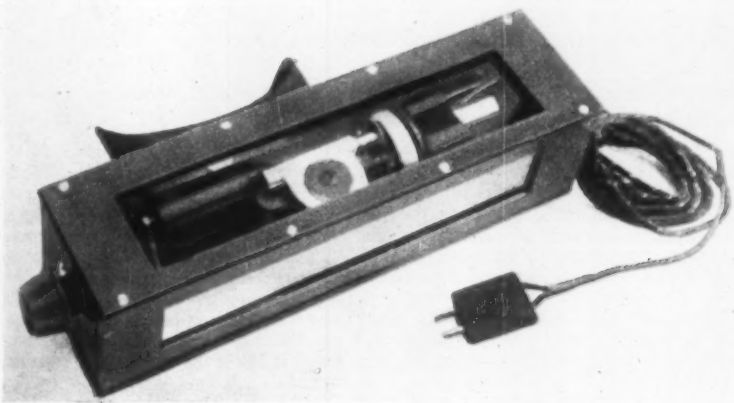
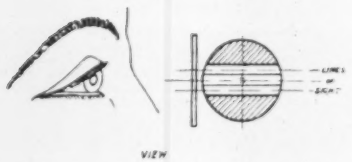


Fig. 595

any other method except that of gravity-driven motion employed in some Standards laboratories. The internal mechanism, Fig. 593, comprises a compound spring which drives, through helical gears, the primary shaft of a gear shifting arrangement which provides (usually) a choice of four ratios. The speed of the primary shaft is usually controllable over a range of 1 to 2. Thus there is available a wide range of glimpse frequencies. With standard shutters this range is 500 to 20,000 per minute; with special spare shutters

this is extended to 100 to 40,000 per minute. The centrifugal governor by means of which the fine adjustments are made is said to provide a "perfect sine or straight-line regulation."

The electrical form of Rotoscope, Fig. 595, is driven from a battery in order to assure constancy of glimpse frequency. Note the knob for fine adjustment of glimpse frequency, and also the revolution counter embodied in the instrument. This counter permits the measurement of average speed with extreme accuracy, provided that some of the precautions listed in Section 2 of this chapter are taken. (Those precautions having to do with



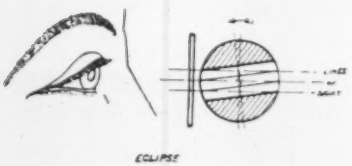
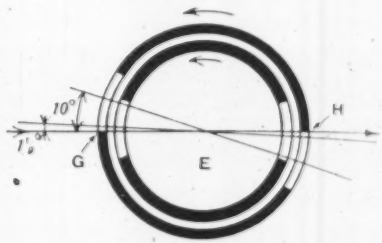


Fig. 596



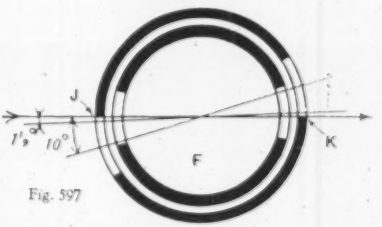


Fig. 597

contact devices are of course unnecessary but on the other hand the value of errors corresponding to the "engagement and disengagement" error depends on the skill of the operator. These errors are of course minimized by long counts.)

Rotoscopes for special purposes are available for measuring up to 1,200 revolutions, oscillations or other cycles per second.

The many different sight gears used in one or the other form of Rotoscope fall into two types, the bladed shutters, Fig. 596, and the "heteroptic" shutters, Fig. 597. Bladed shutters are dynamically balanced metal cylinders weighing less than an ounce, running in jewels, and provided with two openings for binocular vision. These slots have thin metal blades which determine the ratio of vision period to interception-period in each cycle. The shutter shown in Fig. 596 has two blades (three openings) and a movement through 14° opens and closes the aperture with a rapid cut-on and cut-off. The greater the number of blades, the smaller the angle in which a view is obtained. With ten blades the angle of glimpse is about 3½° or one-hundredth of a revolution, so that the vision period is 2% of the cycle—since there are two glimpses every time the shutter makes a complete turn.

Four glimpses per revolution are given by "displaced bladed shutters" by virtue of their having two openings 90° apart whereby the right and left eyes receive alternate views. It is said to be the only means available for observing frequencies as high as 40,000 per minute. The definition is as good as that of the shutters with apertures giving simultaneous binocular glimpses and there is in fact no difference in visual results.

The higher the compounding, the sharper the definition, but in highly compounded shutters the blades are so crowded together that they cause too much loss of light. This led to the design of sight gears employing the various forms of the "heteroptic" shutters, Fig. 597, consisting of two drums rotating at different speeds, which combine high definition with other desired characteristics. The standard heteroptic shutter has a range of 50 to 1800 glimpses per minute. At very low speeds there is some flicker of the image but even then results may be obtained, it is said, which are not possible in any other way, the view being exceptionally

clear. "Hybrid" shutters are a modification of the heteroptic sight gear, the speed ratio of the two cylinders being different and the inner drum having one blade to give a sharper cut-off. The range is 100 to 4000 glimpses per minute.

(g) Interrupted Light Type

The Tackiscope. Fig. 598 shows four views of this French instrument (Robert Donner, U. S. agent) which comprises a housing for a 200-watt incandescent lamp, a motor-driven revolving mirror said to have "a speed range from zero to 33,000 r.p.m.," a friction type governor and a speed indicator.

The case or outer shell is made of cast and tubular aluminum alloy and the working parts are of machined bronze and bakelite. The important elements consisting of a 1/15 h.p. motor, 200-watt incandescent lamp and base,

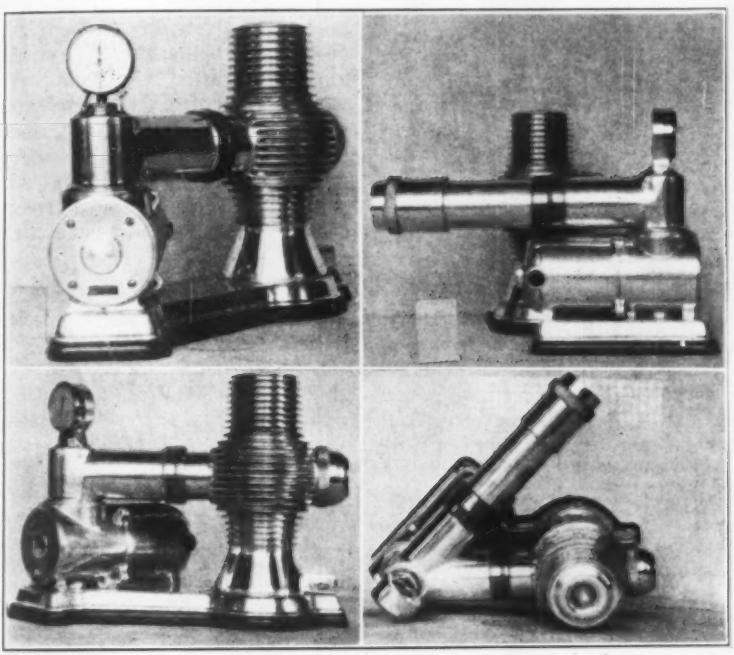


Fig. 598

mirrors, lenses and reflector, are of standard manufacture. The instrument is portable, and can be plugged into any ordinary electric light socket, taking either direct or alternating 25 to 60 cycle service. It is 14″ by 11″ overall and weighs less than 12 lb complete.

Westinghouse Stroboscopic Standards. (Westinghouse Electric & Mfg. Co.) These instruments are principally used for testing watthour meters, and are made in both a panel form interrupted light type and in a portable form intermittent light type. The diagram, Fig. 599, is drawn to show the parts in their actual position on the panel of the interrupted light type instrument, which comprises a panel on which are mounted, one above the other, the standard meter and the meter being tested. The standard meter

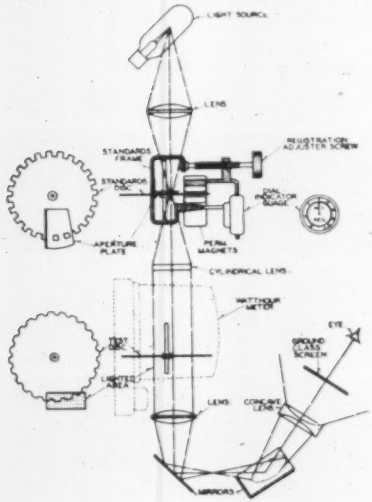


Fig. 599.

has a disk provided with radial slots, and the disk of the tested meter has the usual stroboscopic markings. A projection lamp and lens unit is mounted above the standard meter and an optical system for viewing is mounted on the lower part of the panel. The light is projected through the slots in the standard speed disk, directed through a cylindrical lens and intercepted by the edge of the disk in the tested meter. The intercepted light impulses are then condensed and reflected by the lens and mirrors as shown, so as to be readily observable to the eye. The rotating standard used is provided with a registration adjusting screw which varies the position of the permanent magnet as required to give speeds from 5% slow to 5% fast, and with a dial gage which indicates directly the percent error of the tested meter.

(h) Intermittent Light Type

The Vibroscope, Fig. 600, an American neon-tube instrument (Electrocon Corp.) has a three-lamp projector with an 8-inch reflector. Three or four No. 6 dry cells are normally required but for long periods of operation a 6-volt storage battery is recommended. For low glimpse frequencies an 8-volt battery can be used to give the brilliant flashes which are then necessary when room lights are not turned off. The motor unit, shown on the right, consists of a small universal AC or DC motor, with a breaker head at one end and a governor mechanism at the other. The breaker head has

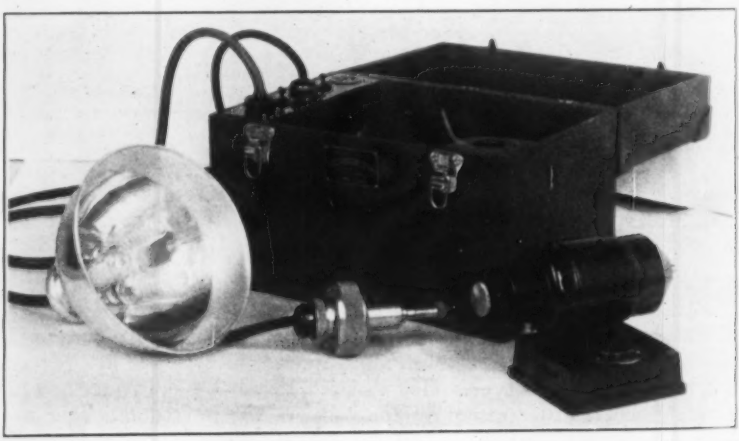


Fig. 600

cam-operated platinum points and gives one flash per revolution. The governor provides a glimpse frequency range of from 700 to 7000 per minute. Speed is measured by a separate tachometer applied to the motor spindle.

This instrument is also provided with a breaker head that can be driven by the mechanism under observation to flash once per cycle regardless of speed; and with a phase adjuster graduated in degrees, whereby the mechanism in cyclic motion may be observed "stationary" at any different position in its cycle.

The Vibroscope weighs 24 lb complete with batteries.

The Stroborama (The Stroboscope Corp.). In its original form, now known as "Type A," this was too cumbersome a piece of apparatus to be suitable for general industrial service and deserve inclusion in this handbook, but the recently brought out "Type B" is much smaller—the size of a baby

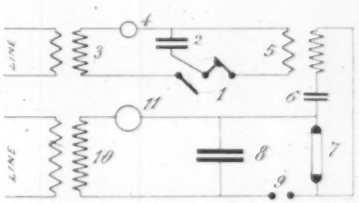


Fig. 601

carriage which its rubber-tired wheels make it resemble. An ultra-powerful neon lamp gives flashes of 1000 candle power. This instrument operates on single-phase alternating current, 50 to 60 cycles, 110 or 220 volts; it takes about 600 watts. Obviously, it is impossible to produce rapid intermittence of the requisite lighting current through a mechanical contact-breaker. Fig. 601 shows how the problem has been solved.

"A rotary synchronizer 1 alternately produces charge of a low capacity condenser 2 into the primary windings of the high frequency transformer 5. This induces a discharge from the secondary of transformer 5 through the condenser 6 and the neon tube 7. The lighting current, stored in condenser 8, has to jump across the spark gap 9 to pass through the neon tube 7. The spark gap is adjusted so that its resistance added to the resistance or the neon tube is too great to allow discharge of the condenser 8. When the controlled passage of the priming current occurs in the neon tube, the resistance of the system is lowered and the current from condenser 8 jumps the spark gap and discharges as a powerful flash through the neon tube. The condenser 8 is kept charged by rectified current from the lighting transformer 10.

"With this combination of elements, the Stroborama produces powerful light flashes of one one-millionth part of a second."

Sharp definition is obtained by such brief flashes, and their intensity is such that Talbot's Law no longer seems applicable; at 50 flashes per second, for example, the ratio of vision to darkness is 50/1,000,000 so that the average candle power would be 1/20,000 of 1000, or 1/20, but the *actual* impression under these conditions is of illumination from a source much more powerful than 1/20 candle-power, because the brain retains for an appreciable time strong messages from the optic nerve.

(i) Stroboscopic Frequency Meters

Mention of these was made in Section 20. The method is the reverse of measuring speed by a known glimpse frequency: it is the disk which rotates at a known constant speed and hence serves as the Standard for measuring glimpse frequency. An important use is the calibration of frequency meters—as well, of course, as of stroboscopes.

Fig. 602 shows a modern and practical set-up. From the description by L. B. Argimbau of the General Radio Company the following is abstracted:

The 1000-cycle output of a General Radio standard-frequency assembly is used as a Primary Standard for the signals driving the synchronous motor. Several graduated disks are employed, each answering a specific frequency requirement. Two such disks (reduced in size) are shown in Fig. 603. It will be noted that disk *A* covers a very wide range of frequencies,

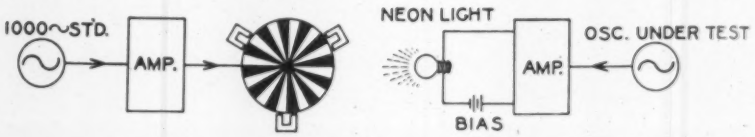


Fig. 602

giving a large number of points. Starting with 10 c.p.s. direct comparisons are possible (with a disk turning 10 revolutions per second) at 10 c.p.s. intervals up to 100 c.p.s. After this, direct comparisons are possible every 100 c.p.s. up to 1000 c.p.s., and then (with the exception of 1500 c.p.s.) every 500 c.p.s. up to 5000 c.p.s.

In addition to these fundamental points, all low rational fractions of these frequencies are available. Thus we have patterns for every 5 c.p.s. up to 50 c.p.s. and every 20 c.p.s. from 100 c.p.s. to 200 c.p.s., etc.; likewise, all even kilocycle points up to 10 kc. are available. As

Fig. 603

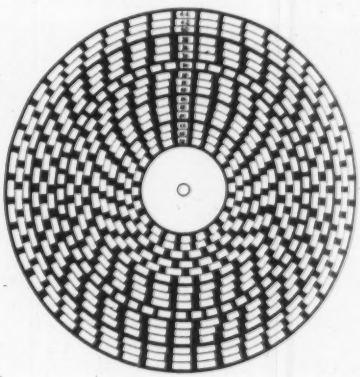


Fig. 604

a matter of fact, it is frequently more convenient to use such multiple patterns than it is to use the fundamentals. For example, when the lamp is lighted from a 60-c.p.s. line, the 300-c.p.s. pattern is immediately noticed, as well as the 60-c.p.s. pattern; rotation of one spot in ten seconds for the 300-c.p.s. pattern indicates a departure of 0.02 c.p.s. or 1/30 of 1 percent in the line frequency.

Disk *B* has been found very convenient for use in calibrating low-frequency tuning forks since a large number of such multiples are present. By its use in conjunction with a stop watch, any preassigned frequency in a restricted commercial range can be measured directly in terms of the primary 1000-c.p.s. standard.

Thus by the use of a synchronous motor in conjunction with a single standard it is possible to cover the range of audio, commercial, and finally of clock frequencies.

26. Automatic Speed Control

(a) Definitions and Fundamentals

The great majority of devices employed for speed control in industry fall into three broad but mutually exclusive classes: (1) those which control the speed of *driven* machinery, (2) those which control the speed of *electric* motors, and (3) those which control the speed of *prime movers*. In general, devices of the first class are variable speed transmissions, devices of the second class are electrical "controllers" and "regulators," and devices of the third class are governors.

Variable speed transmissions are obviously not instruments. Electrical speed regulators as a class are not instruments and few of them include in their design those elements without which a piece of apparatus cannot be classified as an instrument, namely, "primary elements" or "measuring systems" as discussed in Chapter I, Section 4. As to prime mover governors, they fulfill the principal requirements of "automatic controllers" in that they each include two essentials: (1) a speed-responsive element and (2) a means of effecting the required correction—such means ranging from a plain rod between the governor and the throttle to elaborate systems capable of operating large valves. But prime mover governors as a class are not industrial instruments and are excluded from the scope of this manual.*

Therefore, notwithstanding the importance of automatic speed control, the great majority of devices for that purpose are not instruments. Nevertheless the field of speed control is so extensive and the logical applications for standardized industrial instruments are so numerous and diversified that there have been devloped and placed on the market automatic devices which are neither mere transmissions nor single-purpose prime mover governors, but which are instruments in the strictest sense of the word. (See Ch. I, end of Sec. 1.)

We may define an industrial speed control instrument as the *practical* combination of any industrial speed (or frequency) measuring instrument, such as described in foregoing sections of this chapter, with a controlled standardized means (power cylinder, motorized valve, variable speed transmission, electrical regulator, etc.) of increasing or decreasing speed.

Not all speed measuring instruments lend themselves to practical adaptation or development into automatic controllers. For example it is difficult to conceive how a revolution counter could be employed as the primary system of a speed controller. In the case of a resonance frequency meter there would be required a specially designed electric eye or some other at present unusual relay device. In the case of a magnetic drag tachometer the torque is extremely low and the dynamic behavior of the indicating element makes it unsuitable. Practical requirements dictate that the instrument serving as the primary system be of a "familiar" form, as are those being used in industrial automatic controllers of temperature, pressure, voltage, flow, etc.

*For the information of readers of this volume who do not have Vol. I, the following statement is reprinted from Chapter I: All devices known as regulators, controllers or governors incorporated in engines, turbines, generators and other prime movers have been excluded from this treatise. A statement of the reasons may eliminate a source of confusion: These devices constitute essential parts of the machines; they are conceived, designed, built, sold, installed and maintained *with* the machines; they *belong* to the machines and cannot conveniently be studied separately; they seldom can function on other machines; they are not readily classifiable (except into broad types); and finally, their design as a class is not a specialized science, nor their application a specialized branch of engineering, nor their manufacture a specialized industry. It is desired to stress the point that automatic regulation of industrial processing and working conditions is now recognized as a science, that the proper application of standardized industrial instruments to improve products and effect economies is a branch of engineering, and that the manufacture of standardized industrial instruments by several hundred firms in the United States alone, amounts to an industry of importance in its size as well as in its usefulness.

Almost any speed indicating instrument of rugged construction having a pointer that moves fairly steadily and with a torque of, say, 10 gm-millimeters (about 1×10^{-4} ft.-lb) at mid-scale, makes a suitable primary element that requires no depressor-bar mechanism or other complications. There are many makes of these on the market and it seems surprising that only a few have been so much as provided with contactors.

It must be borne in mind, on the other hand, that the speed of machinery in industry may be controlled automatically on numerous applications by instruments the primary elements of which are not speed-responsive. On such applications the primary element responds to an effect which is associated with the speed to be controlled. Where voltage is such an effect, the need for a tachometer generator vanishes; where static pressure is a function of speed, a pressure gage can serve as the primary system; where fluid flow varies dependably with the speed to be controlled, a differential manometer can be used.

All these indirect-control industrial applications may be divided or one might say "graded" into various classes according to the degree of inferentiality of the speed measurement principle utilized by the primary elements. Thus, taking only the static pressure applications, at one extreme of these applications we might have a centrifugal pump the delivery pressure of which (by reason of its discharging into an open tank) has been found by test to vary exactly as the square of the r.p.m. of its drive shaft, except at low speeds. The combination of this pump and a square root scaled pressure gage constitutes a real tachometer. At the other extreme of the pressure-speed applications we might have, say, a stoker-fired boiler the pressure of which varies with the r.p.m. of the motor, turbine or engine that drives the mechanical stoker—provided, of course, that the load carried by boiler, the feed water temperature, feed water rate, air temperature, percent moisture in coal, calorific value of coal and some other factors all remain constant, and that some other factors such as forced draft fan speed vary simultaneously with the stoker motor speed. In the case of the pump it is possible to control the speed by a pressure-responsive primary system; in the case of the boiler it is impossible in practice and only dubiously probable in theory, to control stoker speed by header pressure. Note, however, that in the first case the condition which is desired to be controlled is not speed but flow, and since flow here bears a definite relation to pressure, the condition actually controlled is pressure, so that what we have is an installation of an automatic pressure control instrument. Only incidentally does the duty of this pressure controller happen to be (depending on the pump drive) to turn a rheostat, to shift the brushes of a brush-shifting motor or to operate the throttle of a steam engine or turbine. In the case of the boiler, likewise, we have not so much a speed control application as an installation of a group of correlated control instruments not one of which is a "governor" or a plain automatic control tachometer that regulates speed independently of other conditions.*

(b) Tachometric Controllers

Leaving out governors applied to prime movers, considering only the automatic control of speed of driven machinery, but leaving out also the automatic speed controllers just discussed which are industrial instruments but which regulate speed indirectly or incidentally, we find that the engi-

*The reader need not be a mechanical engineer to appreciate the wastefulness of controlling stoker speed without regard to draft blower speed, damper position, etc.

neering applications thus defined are comparatively limited in variety. Their number is considerable, however, and moreover they constitute what might be called the pure residue or distillate of true tachometric control in industry. We may then reserve the term tachometric controller for an instrument comprising a tachometer for its primary system, with an operative mechanism designed especially for speed regulation and directly controlling the speed of the machine or apparatus, which speed is measured by

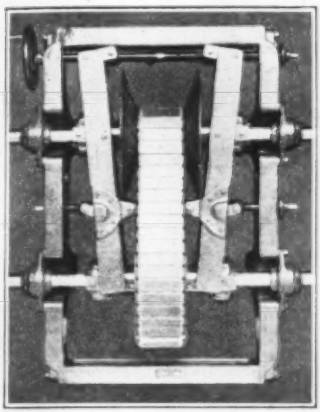


Fig. 614

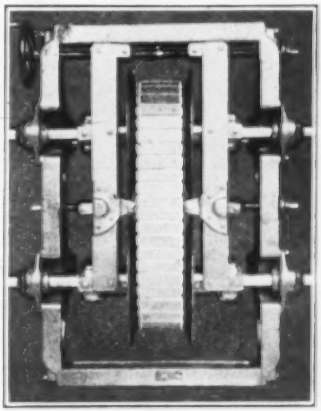


Fig. 615

the primary system. As mentioned toward the beginning of this section the rich variety of indicating and recording tachometers is not accompanied by a corresponding variety of tachometric controllers.

Automatic Temperature Control Co. This concern's Model 300 "three-position controller," a well-known lever-operating power device (previously described in detail in Ch. VIII) has been installed to operate variable-speed transmissions in accordance with impulses received from tachometers equipped with three contacts for high, normal and low. The working contacts are made directly at the tachometric control instrument, or through relays. The Model 300 operative device comes in five sizes, with operating lever arm strokes up to 5 inches giving a pull (at end of arm) of up to 200-lb. The current required, at 110 volts, is from 1/2 to 2 amperes. Reversible motors are series wound, double field type for 110 or 220 volts AC or DC.

Lewellen Mfg. Co. This firm appears to be the only one that furnishes "ready to install" tachometric controllers complete from the measuring instrument to the controlled variable-speed transmission which is interposed between any power shaft and any kind of driven machinery. The electric indicating and recording tachometers as well as the magnetos, contactors, interlocking switches, etc. are of standard makes (see Section 15).

The Lewellen variable speed transmission itself consists of a frame supporting two parallel shafts, upon each of which are mounted two cone-faced disks which may be moved together, or separated, while rotating with the shaft upon which they are spline-mounted. Running between the cone-faces of the disks is a V-type belt which transmits the power from the driving, or constant speed shaft, to the driven, or variable speed shaft. In Fig. 614 the upper disks are farthest apart, while the lower disks are nearest together. This gives the upper

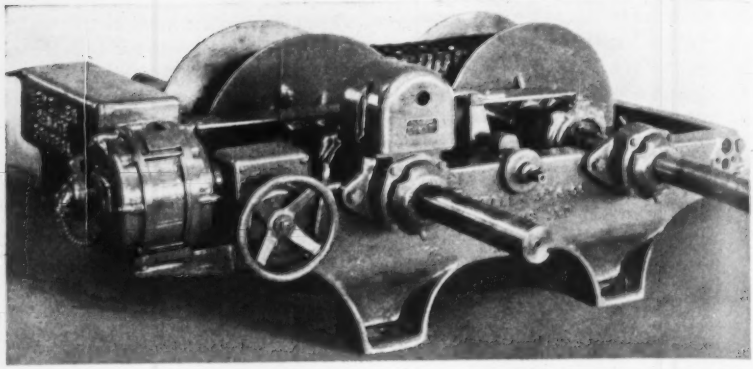


Fig. 615

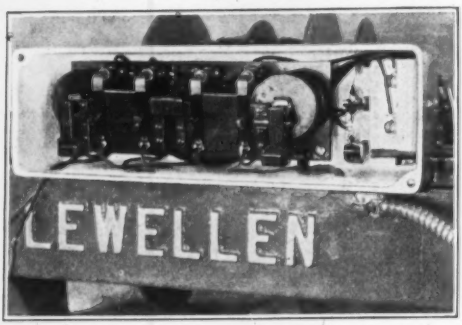


Fig. 617

Fig. 618

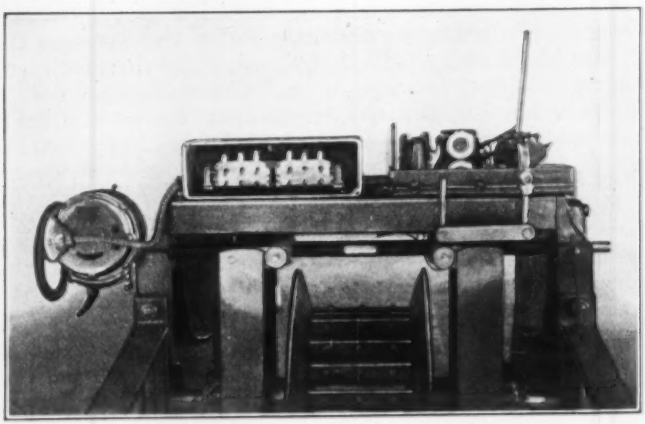


Fig. 619

disks their smallest working diameter, and the lower disks their largest working diameter. Assuming the upper shaft to be the constant speed shaft, then the lower shaft will run at its slowest speed. In Fig. 615, the disks on both shafts are equal distances apart, the belt is running upon equal diameters, and the speed of the two shafts is the same. When the conditions are the reverse of those in Fig. 614, the lower shaft will run at its fastest speed. Either shaft may be used as the constant speed shaft and the transmission may be run in either direction.

The Lewellen *remote control* was developed to enable the operator to give his undivided attention to his work. The best results are secured by locating push button control stations, Fig. 618, at convenient points along the machine so that he may make the proper speed adjust-

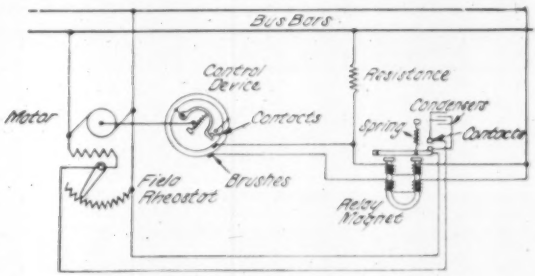


Fig. 620

ment without leaving his position and without diverting his attention. The transmission must necessarily be located at the driving point and some distance from other parts of the machine or conveyor. With remote controls, the push button control station and transmission may be any distance apart. Any number of push button stations may be used, as the motor switch has a mechanical interlock which prevents damage even though two or more push button stations are operated at the same time.

The controlled *power device* is any suitable electric motor for turning the shifting screw of the transmission. Fig. 616 shows its application. In conjunction, there are employed suitable limit switches, interlocking switches, etc., Fig. 617.

The Lewellen *automatic controls* comprise, in addition, a suitable contactor. Fig. 619 shows one end of a Lewellen transmission, equipped with a motor for turning the shifting screw, a contactor device and an interlocking switch device.

Various combinations of the above elements are said to be applicable to practically any industrial process requiring speed regulation, remote control and some other desired results.

(c) Electric Motor Speed Control

Considering only, among the numerous motor speed control systems, those that are fully automatic, one finds a few that may be called instruments and that do not clearly belong in the field of electrical engineering rather than in the province of Instrumentation. It may not be amiss, therefore, to include some brief descriptions here:

Systems with Centrifugal Primary Elements

General Electric Co. Type TD, Form W. At the end of the shaft of the motor whose speed is to be controlled there is mounted a control device of the spring-restrained pendulum class discussed in Section 8, the actual pendulum, however, being single and unbalanced dynamically.

When the field current of the motor with which the control device operates is of small value the contacts of the control device work directly across a resistance in the motor field. When the field current of the motor is of such a value that it can not be handled by the contacts of the control device without excessive burning, one or more relays are interposed depending on the value of the motor field current.

Fig. 620 shows elementary connections for a speed regulator where one relay only is used to handle the field current of the motor.

As will be seen from the diagram, the contacts on the control device close with an increase in speed. When these contacts close a circuit is made through the lower winding on the

relay section, which, being equal to and in opposition to the upper winding, demagnetizes the relay controlling the relay contact, and the spring pulls the relay contacts closed. These contacts short the resistance in the motor field and the motor speed then lowers.

When the speed of the motor decreases the main contacts on the speed control device open, which, in turn, opens the circuit through the lower winding on the relay. The upper wind

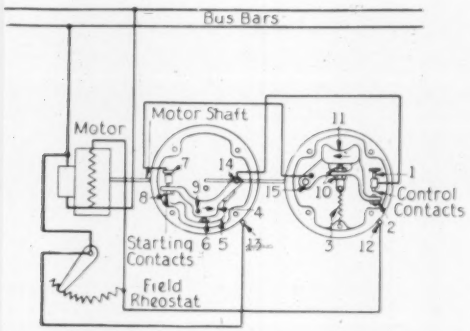


Fig. 621

ing then pulls the contacts open and the short across the motor field resistance is opened and the motor speeds up and the above cycle of operation is repeated.

When the motor field current is of small value, the relays are omitted and the contacts of the control device are connected across the motor field resistance. This connection is shown in wiring diagram Fig. 621.

In certain cases it is desired to have the motor started upon full field; that is, to have the resistance in the field of the motor short circuited by the speed regulator.

To accomplish this a pair of auxiliary contacts are connected in parallel with the main contacts across the rings of the speed regulator. These contacts are normally closed and remain closed until the motor gets up to about two-thirds normal speed, at which point they open and the motor then increases in speed until normal speed is reached; at which point the main contacts close and hold the speed at this value. The auxiliary contacts when used are mounted on an arm on the back of the speed control device. They are held closed at start by a spring which is adjusted to open the contacts as before stated at about two-thirds normal speed of the motor. The connections for this form of regulator are shown in Fig. 621.

The adjustment of spring 5, Fig. 621, is made by means of screw 6. Forcing this screw against the spring will raise the setting; and, of course, relieving the pressure against the spring will lower the setting or opening point. Spring 3 is the main regulating spring and is set to balance the centrifugal force acting against the lever arm 11 at the desired or normal speed. Increasing the tension on this spring will raise the setting and cause the regulator to hold a higher speed, or decreasing the tension will lower the setting and cause the regulator to hold a lower speed. This adjustment is made by means of adjusting nuts 10.

Systems with Electric Tachometric Primary Elements

Allis-Chalmers Mfg. Co. Rocking Contact Type Regulators. These regulators (Brown-Boveri design) are principally employed for voltage regulation of alternators, electric furnaces, battery and booster installations and other electrical engineering applications outside the scope of this section, but they have lately been employed successfully for DC motor speed regulation by having their control elements energized from a tachometer generator directly connected to the motor. Fig. 622 shows the two-sector regulator (there is also a four-sector regulator) and Fig. 623 is a rough diagram which we have made from an Allis-Chalmers blueprint, to show the essentials.

The tachometer generator 2, Fig. 623, is directly connected to the motor, the speed of which has to be automatically controlled. This pilot generator is a shunt wound, self-excited generator working in the straight part of the saturation curve where a relatively small speed change results in a wide variation of generator voltage. The control coil of an Allis-Chalmers quick acting voltage regulator is connected to this pilot generator through an adjusting rheostat 6. The voltage regulator 3 controls the speed of the direct current motor 1, in such a way as to maintain a constant voltage on the pilot generator. By means of the changeover switch 4, the regulator 3 can be disconnected and the speed of motor 1 can be regulated by hand by means of rheostat 5.

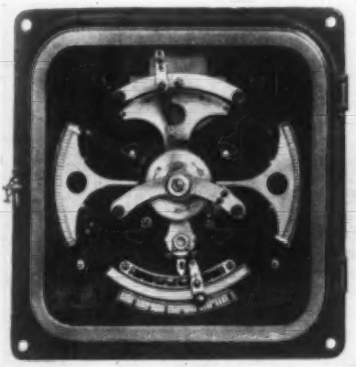


Fig. 622.

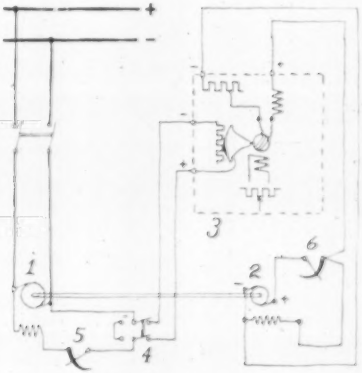


Fig. 623

If the speed of the motor 1 is too high, the pilot generator creates a correspondingly high voltage which causes the voltage regulator to turn so as to strengthen the field of the main motor, until its speed is brought back to the desired value. If the speed of the main motor is too low, the voltage generated by the pilot generator falls and allows the spring of the regulator to overcome the torque developed by the control element thus weakening the field of the main motor to such an extent that normal speed is reestablished.

The adjusting rheostat 6 is carrying the sum of the currents in the field winding of the pilot generator and the control coil of the voltage regulator. If the amount of resistance in this rheostat is increased, a higher speed and voltage on the pilot generator are necessary to maintain the regulator in balance.

This method of connection gives a very sensitive regulation and at the same time limits the undesirable but commonly occuring temperature effects caused by the varying resistance of the field winding of the pilot generator. This field winding being connected in parallel with the regulator control is always under a constant voltage.

Speed adjustment of the main motor is taken care of by the adjusting rheostat 6.

The pilot generator 2 is preferably direct connected to the main motor 1 where the motor speed is not too low. Belt or chain-driven pilot generators are preferably used where the motor speed is very low. It is evident that the higher the speed of the pilot generator the lower its cost and the quicker its response to speed variation.

For total speed ranges above 4 to 1, it is necessary to use two pilot generators connected directly to the main motor shaft, one pilot generator being used over the lower speed range and the two generators connected in series are used over the higher speed range. For this arrangement it is possible to keep the maximum pilot generator voltage within safe operating limits. This arrangement has to be recommended where all the speed adjustments of the drive have to be made from a centrally located control board. It is, however, possible to use one pilot generator only, provided it is driven through a two or three stage pulley or other means of changing the speed ratio between the pilot generator and the main motor.

The design of the different parts of the regulator itself, and their general arrangement, are shown in Fig. 624. The device is built on the principle of the induction motor. The stator laminations E are circular and carry a split phase winding. Concentric with the stator pole faces is a cylindrical soft iron core, which completes the path of the field lines, leaving only a small air gap. In the field in this air gap is placed a thin hollow drum of aluminum C carried

by a steel spindle, the latter being supported at both ends by jewel bearings. The electric torque produced by the current in the split phase winding is counterbalanced by a combination of two springs, which produce a constant torque whatever the position of the drum may be. A sufficiently high resistance is connected in series with the stator winding to prevent variations in temperature and small variations in frequency having any marked effect.

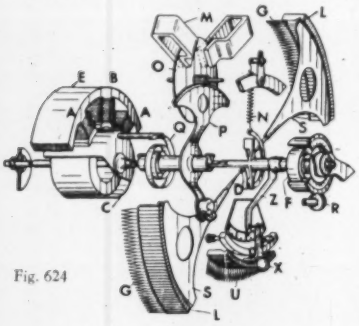


Fig. 624

The field rheostat with contact device is an integral part of the regulator. The stationary contacts L to which the resistance coils G are connected are arranged concentrically with the rotor spindle. The inner side of these contacts, facing the spindle, is provided with a V-shaped groove that serves as a guide for the moving contacts S. The latter have the shape of a sector, with a curved strip of silver or carbon as contact surface and a steel needle as pivot. The latter rests in a jewel cup, which is carried by a leaf spring D supported from the rotor spindle. The rotor can be turned through an angle of 60° and in doing so carries the two needle points over the corresponding arc of a circle. This causes the sectors S to roll in the groove of the stationary contacts L, putting in or cutting out resistance. This design of the field rheostat eliminates gliding friction and replaces it by rolling friction which is negligible. All moving parts are made of aluminum. Therefore the inertia is small, and as only small displacements are required to cover the whole regulating range, the moving system responds very quickly to changes in voltage.

To prevent overshooting, the regulator is provided with an elastic recall device, the purpose of which is to stabilize its operation. It consists of an aluminum disk O rotating between two permanent magnets M. The disk is geared to the rack of an aluminum sector P, which can turn concentrically with the rotor spindle and is fastened to the aluminum drum C by means of a flexible spiral spring Q, acting as a recall spring. If a change in voltage occurs, the eddy currents induced in the disk O tend to resist quick response of the moving system. However, thanks to the flexible coupling, the drum, which directly controls the contact sectors S, will immediately take up a position in which the torque of the various springs and the electrical torque are again balanced. The coupling spring between the drum and the disk is made weak enough to allow powerful over-regulation and yet maintain perfect stability.

General Electric Co. Type TSC, Forms E, E2, E3 and E4. The function of each of these regulators is to maintain the speed of a shunt-wound direct-current motor within reasonably close limits. They may be used to control the speeds of several motors individually, balancing them against a common standard and thus maintaining a fixed relationship among them, such as a group of individual roll drives on a continuous steel mill. Also they may be used to control the speed of one or more motors to cause them to follow the speed changes of another drive, such as the edger rolls following the speed changes of the main rolls of a steel mill.

"Each regulator consists of the following essential parts: (1) Main control element (balanced type of relay); (2) Auxiliary relay, through which the contacts of the main control are relayed; (3) Direct-current pilot generator, which interprets the speed of the main motor being regulated; (4) Counter E.M.F. generator, forming medium through which the regulator operates on the field of the main machine." Note that No. 3 is the primary element, for whose function the General Electric Co. uses the expression "interpreting."

The general arrangement of the relays, etc., forming one of the regulators is shown in Figs. 625 and 626.

The operation of one of these regulators may be understood by referring to the elementary diagram, Fig. 627. It will be noted that the main motor is separately excited from the direct-current bus. There is in series with the shunt field the armature of a machine that generates a voltage in opposition to the bus voltage. This opposing voltage is termed C.E.M.F. By

controlling the shunt field of this C.E.M.F. machine, the shunt field current of the main motor may be varied to control the speed of the machine. The C.E.M.F. generator in this way serves as a medium through which the regulator may operate, and because of working indirectly through the field of the small C.E.M.F. generator, the current to be handled by the regulator is small compared to the shunt field current of the main motor. This C.E.M.F. machine is usually driven by a separate motor not shown in Fig. 627.

There is connected to the motor a small direct-current pilot generator PG, receiving separate and constant excitation. Consequently, *the voltage developed by this generator is a measure of speed, and is used for operating the speed regulator.*

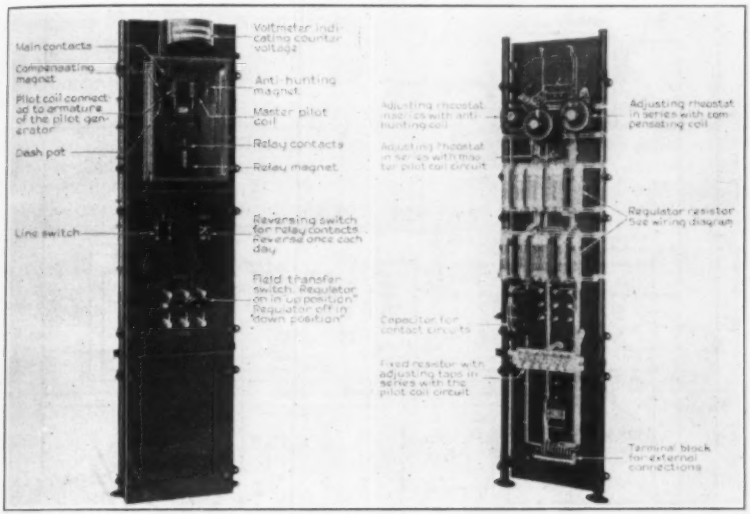

Main contacts
Compensating magnet
Pilot coil connected to armature of the pilot generator
Dash pot
Line switch
Voltmeter indicating counter voltage
Anti-hunting magnet
Master pilot coil
Relay contacts
Relay magnet
Reversing switch for relay contacts reversed once each day
Field transfer switch. Regulator on in up position. Regulator off in down position
Adjusting rheostat in series with anti-hunting coil
Adjusting rheostat in series with master pilot coil circuit
Capacitor for contact circuits
Fixed resistor with adjusting taps in series with the pilot coil circuit
Adjusting rheostat in series with compensating coil
Regulator resistor
Terminal block for external connections

Fig. 625 Fig. 626

The speed regulator consists mainly of a balanced relay BR, with two main elements MM and PM. The element MM is the master coil that is connected in series with corresponding coils of the other regulators and energized directly from the bus. The other side of the relay PM is a coil that is connected directly to the pilot generator PG, and is the main control element governing the operation of the regulator. The magnetic pull of the coil PM is supposed to balance, at all times, the magnetic pull of the master coil MM. It is the function, therefore, of the coil PM to cause the regulator to raise or lower the speed of the main motor and thus affect the voltage developed by the pilot generator PG until the balance is obtained.

The relay RM is a secondary relay, the contacts of which are connected across the field of the C.E.M.F. machine. This relay has two coils which are wound to oppose each other. The upper section of the relay winding shown is continuously energized and opposes the spring to hold the relay contacts open. The lower section of the winding, when energized through the contacts of the main regulator BR, counteracts the effect of the upper section and allows the spring of the relay to close the contacts C2. The relay contacts C2, therefore, operate simultaneously with the main contacts C1 to control the field of the C.E.M.F. machine.

The cycle of operation of the regulator may be described as follows: The coil PM, being connected directly across the armature of the direct-current pilot generator PG, draws a current sufficient to produce the required magnetic pull to balance the magnetic pull produced by the master coil MM. Should the speed drop on the main motor, thereby reducing the voltage of the pilot generator and current flow through the coil PM, the regulator would become unbalanced in the direction to cause the main contacts C1 to open. These contacts control the relay LR, causing its contacts to open and thus allow the field strength of the C.E.M.F. machine to increase. The result is an increase in the voltage developed by the C.E.M.F. machine, which is in series with and in opposition to the field of the main motor. Thus the increased counter voltage reduces the current flow through the field of the main motor, causing it to increase in speed. Conversely, should the speed of the main motor be high, then the coil PM will overbalance the coil MM to cause the contacts C1 to close, which,

in turn, allows the contacts of relay RM to close, short-circuiting the shunt field of the C.E.M.F. machine; this reduces the counter voltage, allowing greater current to flow in the field circuit of the main motor B, and thereby causing a reduction in speed. Consequently, by the process of repeated cycles, the contacts C1 and C2 vibrate continuously, opening and closing and maintain a sufficient voltage on the C.E.M.F. machine to produce the proper field current and speed of the main motor to maintain the balance of the regulator. It is because of this continuous opening and closing of the contacts that the regulator is called the vibrating type.

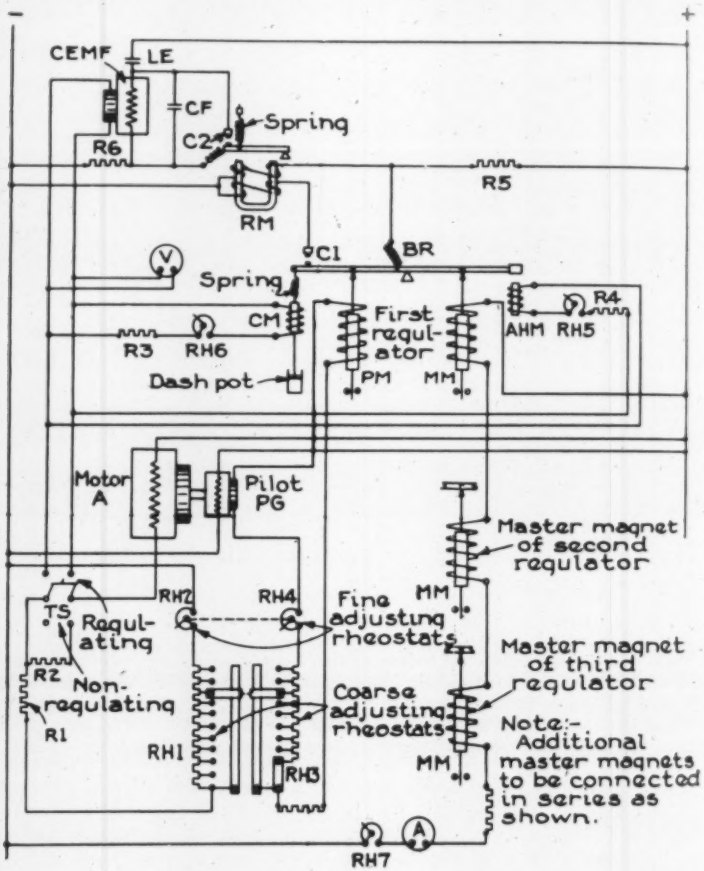


Fig. 627

For the successful operation of most vibrating regulators some form of anti-hunting is needed. Anti-hunting effect is obtained by the magnet coil AHM which, when the main contacts open, resulting in increased counter voltage of C.E.M.F., immediately produces a greater pull of the magnet AHM, causing the balancing arm to tip to close the contacts C1. This anti-hunting action produces a slight compounding effect when operating over the counter voltage range, and to overcome this effect it is counter-balanced by a compensating torque produced by the coil CM. The magnet core of this coil is free to move and is suspended by means of a spring from the end of the lever arm opposite the anti-hunting magnet. The movement of the core in the coil CM is damped by means of a dashpot. The effect of the spring and dashpot is such that the anti-hunting action of coil AHM is not interfered with and at the same time the sustained effect of the coil CM exactly compensates for the compounding effect. Both the anti-hunting and compensating coils are connected across the armature of the counter voltage machine (C.E.M.F.) and are affected directly by the change in voltage produced by the opening and closing of the main contacts C1 of the regulator.

The fact that the master elements MM of all the regulators are connected in series produces a synchronous tie among the speeds of the various motors that are being regulated. By means of the rheostat RH7 in this circuit the speed of all machines may be controlled collectively through a reasonable range. Individual control of each motor, which is necessary for the successful operation of a given installation, is obtained by rheostats RH3 and RH4 which are connected in series with the main operating coil PM. With these rheostats the speed of each motor may be adjusted to operate at any point within its speed range. The rheostat RH3 gives coarse adjustment and the rheostat RH4 fine adjustment of the speed of the motor.

Naturally the relay coils PM and MM are most sensitive to changes in flux at a definite current and resulting flux density. The range, therefore, over which they will operate satisfactorily is limited and care must be exercised when making adjustments of these circuits. It is for this reason that an ammeter A and adjusting rheostat RH7 are used in the master coil circuit.

Voltmeter V is for indicating the C.E.M.F. voltage to facilitate adjustment.

Contact LE is an interlock which is furnished on the line contactor for the small motor which drives the C.E.M.F. generator and is furnished as part of the control equipment. It is used to disconnect automatically the field of C.E.M.F. when the set is stopped. Contact CF is the contact of a relay, furnished as part of the control, which takes the regulator out of service during the acceleration of the motor to basic speed by the control equipment.

During normal operation of the regulating equipment all necessary adjustments may be made by the operator in the pulpit. Small adjustments of speed are taken care of by means of the adjusting rheostats RH-2 and RH-4 operated by a single handle. Large adjustments of speed are taken care of by means of the push-button controlled, motor-operated, combination rheostats RH-1 and RH-3. The respective speed of each motor with respect to drive "A" is controlled by means of RH-7 over a small range.

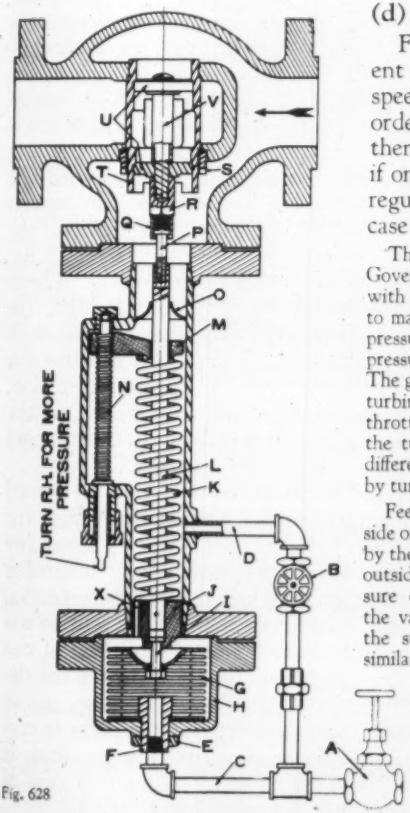


Fig. 628

(d) Indirect Control of Speed

From among the hundreds of different methods and applications wherein speed is controlled automatically in order to control some other condition, there may be selected just one example, if only to illustrate how incidental the regulation of speed is in practice, in the case of instruments so employed.

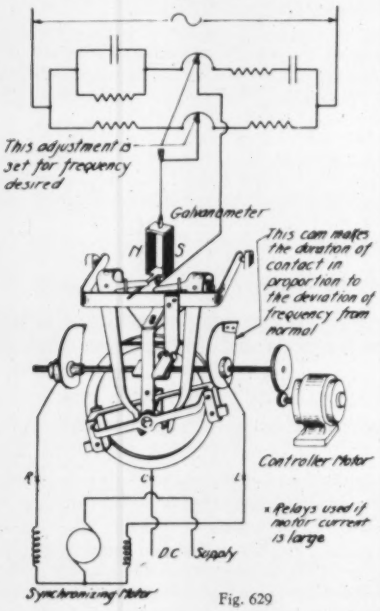
The Bailey Meter Co. Boiler Feed Pump Governor, Fig. 628, is designed primarily for use with turbine driven pumps, its purpose being to maintain a constant differential between the pressure of the steam leaving the boiler and the pressure of feed water in the feed water line. The governor is installed in the steam line to the turbine and controls differential pressure by throttling the steam supply and consequently the turbine speed. It is set for any desired differential by adjusting the tension of spring K by turning screw N.

Feed water pressure is transmitted to the inside of the sylphon G, this force being balanced by the steam pressure and the spring K on the outside of the sylphon. When the steam pressure decreases, the sylphon expands, moving the valve mechanism upward, thus throttling the supply of steam to the turbine. In a similar manner, more steam is admitted to the turbine when the steam pressure rises. To by-pass the governor, valve A is closed and valve B is opened, thus equalizing the pressure on the inside and outside of the sylphon so that the spring will hold the valve in its open position.

(e) Automatic Frequency Control

In multi-unit stations, automatic control of frequency may be achieved by means of electrical instruments and apparatus some of which are classifiable as industrial instruments, but this application may properly be assigned to the electrical instrument chapters. Single-unit station control, however, is of wider industrial interest. One example may therefore be given, of fully automatic instrumental control.

Leeds & Northrup Co. Proportional-step Controller. The potential from the station bus feeds a frequency-sensitive bridge shown diagramatically in Fig. 629 which is somewhat similar in construction to that employed in the L & N frequency recorder described in Section 20. When the frequency varies from the control setting, the controller galvanometer, which is simply a detector of current unbalance, is deflected in a direction depending upon the unbalance current through the bridge. The direction of this current is in turn determined by whether the frequency is high or low.


This adjustment is set for frequency desired
Galvanometer
N
S
This cam makes the duration of contact in proportion to the deviation of frequency from normal
Controller Motor
* Relays used if motor current is large
DC Supply
Synchronizing Motor
Fig. 629

The deflection of the galvanometer pointer is picked up by the controller mechanism, and closes contacts which operate the governor-synchronizing motor, changing the tension on the governor spring, thereby changing the position of the turbine throttle. These controller contacts are connected in parallel with the contacts on the governor switch (which, in manual regulation, the operator would close to send an impulse to this same motor). Therefore, if the frequency is high, the deflection of the galvanometer sends an impulse to run the synchronizing motor in the direction to close the throttle, and if low, the impulse runs the motor in the opposite direction. This is exactly the procedure which the operator follows, except that the frequency controller is sensitive to variations of the order of 0.01 cycle, and it starts to correct before the deviation in frequency is appreciable.

When frequency deviates, it might of course be brought back to normal by either varying the number of impulses in a given time or by varying the duration of a given impulse. It has been found more satisfactory to employ this latter scheme, and one of the features of the proportional-step controller is the design of the cams and contact mechanism which makes this correction possible. This design is such that the duration of the impulse sent to the governor motor is directly proportional to the amount of deviation of the frequency from the control setting. This means that the greater the deviation from the control setting, the greater the correcting impulse, and as the frequency approaches the control point, the correcting impulse is correspondingly decreased. This feature accomplishes two things—first, it brings the frequency back to normal much more rapidly than an impulse of unvarying duration, and second, it prevents overtravel or hunting.

Measurement of Air Flow

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CHAPTER IX (Cont'd)

Inclined Tube Manometers.—If a small sacrifice of accuracy, and the advantage attendant upon the use of an instrument which does not require calibration, are considered unimportant, a convenient form of gauge suitable for factory use will be found in the Krell manometer, shown diagrammatically in Fig. 54. The principle of this instrument is simple: if one of the arms of a U-tube is inclined at a small angle to the horizontal, the liquid in that arm will move a considerable distance along the tube for a small amount of vertical motion, i.e. for a small applied pressure difference. Reference to the diagram shows that the gauge consists essentially of an inclined tube A, which forms one arm of the U-tube, and a large reser-

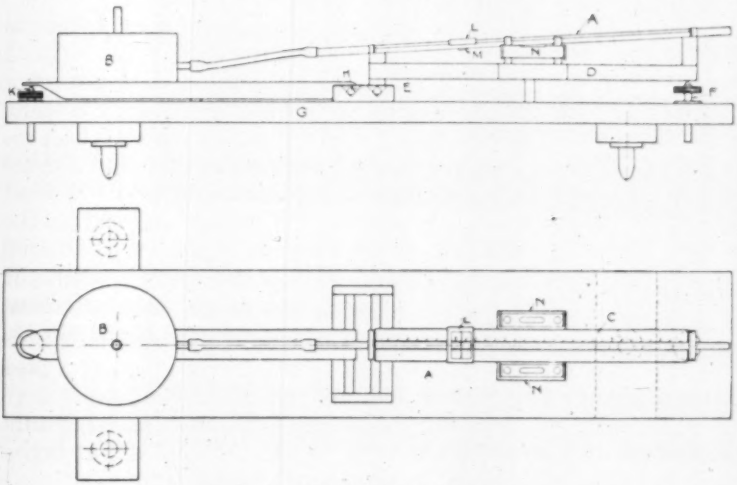


Fig. 54.—Krell type inclined tube manometer.

voir B, having an area several hundred times that of the tube, forming the other arm. The sources of pressure are connected to the reservoir and to the end of the inclined tube; the use of a large reservoir causes the liquid level therein to remain virtually stationary, practically all the motion occurring in

the tube, where the position of the meniscus is observed against a graduated scale C.

The tube is held on the frame D, which is pivoted at E, and can be raised or lowered at the other end by means of the screw F, so that the inclination of the tube can be altered and the sensitivity and range thereby varied. The whole instrument is mounted on a baseboard G, fitted with three levelling screws, and provision is made for rotating the reservoir support about the fulcrum H by means of the screw K, in order to adjust the zero level of the liquid in the inclined tube. For observing the position of the meniscus it is convenient to have a sliding frame L, which moves along the scale and carries a cross wire above the tube, and a small strip of white ivorine M below.

It is usual to provide two spirit levels NN, which are adjusted and locked when the manometer is initially calibrated so that the tube may be set to two definite inclinations. The instrument then has two ranges for indicating low and high pressures respectively. The advantage of this will be realised when it is remembered that the velocity head is proportional to the square of the wind speed, and that it is usually necessary to allow for the measurement of fairly high speeds. If, therefore, the tube is set to such an inclination that the full scale reading corresponds with the highest wind speed liable to be encountered, the readings for low wind speeds will be small, and very little accuracy will be obtained in this range.

Alcohol is found to be the liquid giving the best meniscus in this type of manometer. As regards the bore of the inclined tube, a diameter of about 0·2 inch gives the best results ; * a convenient length of tube is one with which a full scale reading of 12 inches can be obtained. With such a tube set at an inclination of 11 degrees, the highest pressure indicated, if alcohol is used as the manometric liquid, will correspond with a wind speed of about 80 feet per second. If this is adopted as the higher range, a convenient lower range will probably be found to be that in which the second level is set at $2\frac{1}{2}°$, when the maximum pressure will correspond with an air speed of about 40 feet per second. The scale can be read to about 0·02 inch, and an accuracy of 3 per cent. or so will be obtained at a pressure corresponding with 10 feet per second on the lower range. If this degree of accuracy at low speeds is not considered sufficient, the levels can be adjusted to smaller angles ; at higher speeds the precision is, of course, much better.

The manometer is not a fundamental standard, and requires calibration against a primary manometer, since various factors, such as lack of straightness of the inclined tube and surface tension effects, due to want of uniformity in the bore,

* Hunsaker, *Smithsonian Misc. Coll.* vol. 62, p. 34.

preclude the possibility of calculating true pressures sufficiently accurately from the observed readings and the known inclination of the tube. In order, however, to estimate initially the angle to which the tube should be set for any desired range, the following formula will give sufficiently exact results. It is the formula which would be valid if the instrument were not subject to the errors mentioned above :—

$$\text{Sin } \theta = \frac{h}{l\sigma}, \quad . \quad . \quad . \quad . \quad (3)$$

where h is the maximum water column to be observed,
l is the total length of the scale,
σ is the specific gravity of the liquid,
and θ is the required slope of the tube to the horizontal.

Manometers of this type are to be recommended for general use : when calibrated they are accurate and consistent in their readings and comparatively inexpensive when their degree of performance is taken into consideration. They are, moreover, convenient and robust, and by their aid observations of pressure can be rapidly performed. The only disadvantage is the fact that each manometer requires calibration initially against a standard instrument. A certificate giving the results of calibration can be obtained by submitting the instrument to the National Physical Laboratory for test ; in many cases the manufacturers will obtain an N.P.L. certificate and supply it with the gauge. If an absolute standard, such as the tilting micromanometer, is available, the calibration can easily be carried out in the manner described at the end of this chapter.

A modification of the inclined tube manometer has been designed by Hodgson, in which the manometer tube, instead of being inclined at a constant angle along its entire length, is curved in such a manner that a uniform scale of velocity is obtained. This instrument is particularly useful when, as is often the case, it is desired to have an instrument continuously installed to indicate instantaneously the speed or quantity of air flowing in a pipe line. A form of this manometer fitted with a pressure scale is shown in Fig. 55, which is reproduced by the courtesy of Messrs. George Kent, Ltd., Luton. With a velocity scale the instrument can be used, together with the Pitot and static tube, to indicate speed in any pipe, but with a quantity scale it can, of course, only be used for the particular pipe for which it is designed.

Instruments of this type, in addition to the advantage they offer in enabling wind speeds to be rapidly determined, have the merit that a wide range of speeds can be observed with one tube at a constant setting. On the other hand, they are probably not so convenient for general use as instruments graduated directly in terms of pressure, since they can only be em-

ployed to measure pressures by fitting them with a different tube and scale. It must also be remembered that a particular velocity (or quantity) scale is only accurate at one particular value of the air density; as this property varies with temperature and pressure, corrections have to be applied to the readings. Normally, however, these corrections will be quite small. Attention is drawn to this point in the discussion of the theory of the instrument given at the end of the present chapter.

Large Range Micromanometers.—A useful and robust type of manometer is that employing virtually a flexible U-tube, consisting of two limbs whose lower ends are connected by a length of rubber tubing One of the limbs remains stationary

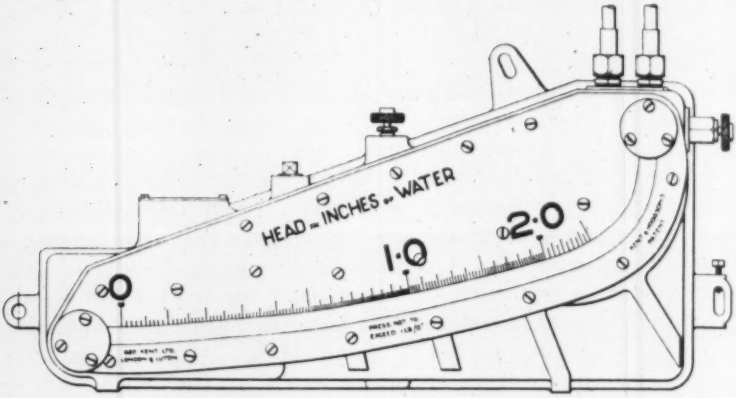


FIG. 55.—Curved tube manometer.

whilst the other is raised or lowered, by an amount corresponding to the applied pressure difference, by means of a micrometer screw to which it is attached. Fig. 56 illustrates a manometer which utilises this principle and incorporates some useful features introduced at the University of Toronto.* The construction of the instrument is clear from the figure, and needs little comment. Rotation of the nut supporting the movable limb of the U-tube is prevented by means of a keyway, which engages with a vertical key cut on the right of the vertical supporting standard carrying the head of the micrometer screw. In place of a cup for the moving limb, an inclined glass tube of variable slope is employed having a line etched on it. The zero reading is first established with the liquid meniscus in this tube in coincidence with the fixed mark. When a pressure difference is applied the inclined tube is raised on its nut until the liquid is again in equilibrium at the mark. Complete turns of the micrometer screw are indicated by the pointer moving over the vertical scale, whilst fractions of a

* *School of Engineering Research*, Bulletin No. 2, Paper No. 1, 1921 (J. H. Parkin).

turn are observed on the graduated head. The fixed limb of the U-tube consists of a reservoir of large cross-sectional area

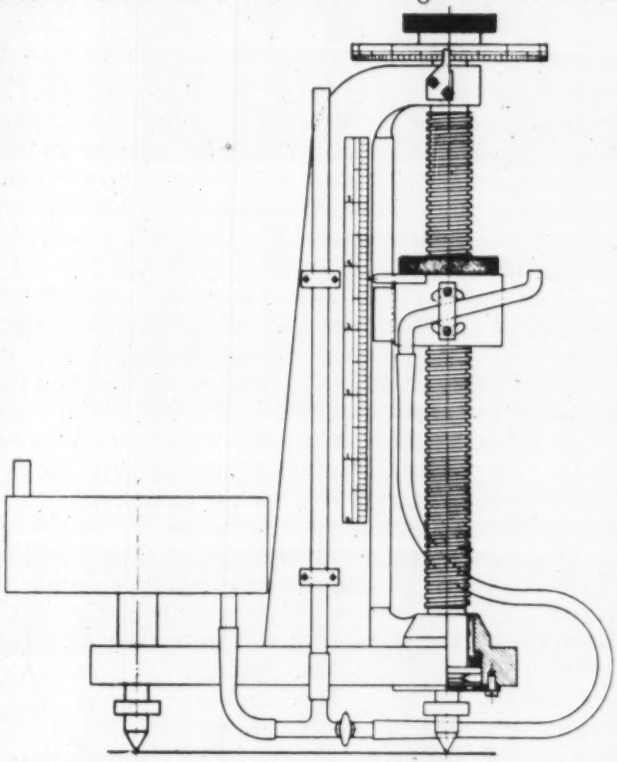


FIG. 56.—Large range micromanometer.

in comparison with that of the inclined tube, so that the change in level in the reservoir can be neglected. A convenient feature of this manometer is the vertical glass tube fixed alongside the scale as shown. This tube is connected to the reservoir in parallel with the inclined tube by means of a T-piece, and if its open end is connected to the same source of pressure as the open end of the inclined tube, the level of the liquid in it indicates the approximate height to which the nut should be raised when the order of magnitude of the applied pressure difference is unknown beforehand. The final adjustment is made by the aid of the meniscus in the inclined tube.

As in all types of manometer in which the meniscus in an inclined tube is observed, alcohol is found to be the most suitable liquid, and the best sensitivity for general use appears to be obtained by the use of an inclined tube of about 0·2-inch bore set at a slope of 3° or so, corresponding to a magnification of roughly 20 to 1. With smaller slopes no appreciable increase of sensitivity can be gained without making the instrument unduly sluggish. Tubes of smaller bore reduce the sluggish-

ness to some extent, but the meniscus is not so good.

This instrument, though not as simple or rapid in use as the plain inclined tube manometer, is certainly more accurate, and has the advantage that it does not require calibration; the readings need correction only for the specific gravity of the alcohol used, in order to convert them into inches of water. Once the accuracy of the micrometer screw thread has been checked the manometer can therefore be used as an absolute standard. It is stated * that the movement of the liquid column can be read to within about 0·0002 inch on the average, with an extreme possible error of 0·0005 inch. A further important advantage of this instrument is the fact that the range is not as restricted as it is in other sensitive manometers, since the micrometer screw may be made 10 or 12 inches long.

A manometer similar in principle and construction to that just described has been designed for use at the National Physical Laboratory.* In this instrument the equilibrium position is determined in a different manner. The two limbs of the U-tube in this case consist of two glass cups similar to those used in the tilting manometer. One of these cups is raised or lowered by means of the micrometer screw, whilst the other is fixed. The latter cup is constructed as shown in Fig. 57; it will be seen that the arrangement is precisely similar to that of the central vessel in the Chattock manometer, and, as in that instrument, use is made of a water-paraffin meniscus on the mouth of the central tube to indicate the equilibrium position. The meniscus is suitably illuminated and is viewed through a microscope. For the zero setting the meniscus is adjusted so that its image coincides with the intersection of the cross wires in the eyepiece of the microscope; an applied pressure difference is then balanced by adjusting the level of the movable cup until the image of the bubble once more coincides with the intersection of the cross wires. In this instrument, the cross-sectional area of the rubber connecting tube is not small compared with that of the cups. Hence in order to avoid appreciable errors due to change in volume of the rubber tubing, it is advisable to have a long length of tubing so that it hangs approximately vertically from each cup over the entire range of the movable cup. The changes of shape that then occur in the tubing will only produce negligibly small volume changes.

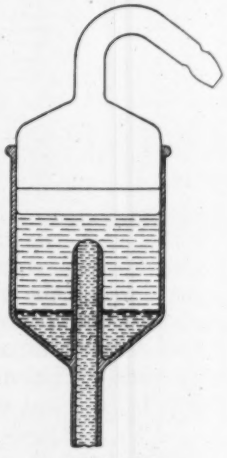


FIG. 57.

* Parkin, *loc. cit.*

N.P.L. Report for 1921, p. 170

The Two-Liquid Differential Manometer.—A convenient instrument for work where high accuracy is not required is shown in Fig. 58. It is, in reality, a modified form of U-tube, magnification of the readings being secured by the use of two non-miscible and mutually insoluble liquids of nearly equal densities. A serious fault of the plain U-tube—namely, zero errors due to tilt of the instrument—is overcome in the manometer under consideration by arranging the two limbs concentrically as shown.* Each limb is surmounted by a reservoir, connection to the reservoir of the inner tube being made by means of a short glass tube passing through the top of the outer reservoir, to which it is sealed on the outside as shown. The two liquids are arranged with the lighter one in the inner tube, the surface of separation or meniscus being near the upper end, and pressure readings are obtained in terms of the movement of the meniscus down the central tube. The pressure difference should be applied so that the higher positive pressure acts on the inner reservoir, thus giving a downward movement to the meniscus.

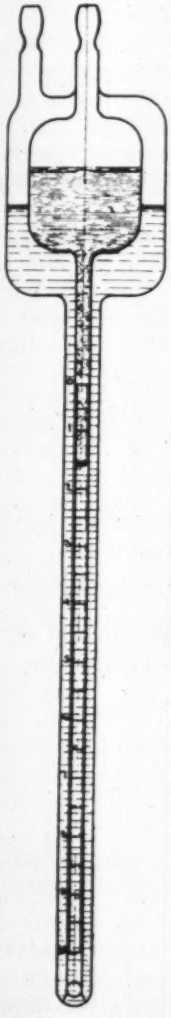


FIG. 58. — Two-liquid differential manometer (concentric tubes).

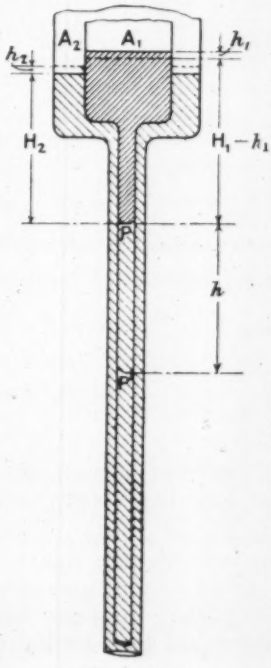


FIG. 59.

The relation connecting the applied pressure difference in inches of water with the movement of the meniscus can easily be deduced as follows :—

In Fig. 59 let A_1 and A_2 be the areas of the inner and outer reservoirs respectively, and *a* the

* This type of two-liquid manometer was originally designed at the Royal Aircraft Establishment for use on aeroplanes, see Reports and Memoranda of the Advisory Committee for Aeronautics, No. 144. The instrument mentioned in this Report had the lighter liquid in the outer reservoir, the surface of separation of the two liquids being in the outer tube. The form here described is preferable, since a more definite meniscus is obtained.

area of the central tube. Also, in the zero equilibrium position before a pressure difference is applied, let the boundary between the lighter and heavier liquids be at a point P in the central tube such that the free levels in the two reservoirs are at heights H_1 and H_2 above P as shown. Also let σ_1 and σ_2 be the specific gravities of the lighter and heavier liquids respectively.

From a consideration of the equilibrium of the liquids in the inner and outer tubes at the level of the point P, we have the equation,

$$H_1\sigma_1 = H_2\sigma_2. \quad . \quad . \quad . \quad (4)$$

Now let a pressure p inches of water be applied to the inner reservoir. The meniscus will move down a distance h to the point P′ and at the same time the level in the inner reservoir will fall and that in the outer reservoir rise, by amounts h_1 and h_2 respectively.

The equilibrium condition for the level P′ now becomes

$$p + (H_1 - h_1 + h)\sigma_1 = (H_2 + h_2 + h)\sigma_2. \quad . \quad (5)$$

The volume of liquid displaced in each reservoir must be equal to the volume of liquid displaced in the inner tube. That is

$$ah = A_1h_1 = A_2h_2.$$

Hence we may write

$$\left.\begin{aligned} h_1 &= \frac{a}{A_1}\,h, \\ h_2 &= \frac{a}{A_2}\,h. \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Substituting the relationships of equations (4) and (6) in (5), we obtain

$$p_1 + h\sigma_1\left(1 - \frac{a}{A_1}\right) = h\sigma_2\left(1 + \frac{a}{A_2}\right),$$

or

$$p = h\left[(\sigma_2 - \sigma_1) + \frac{a(\sigma_1A_1 + \sigma_2A_2)}{A_1A_2}\right], \quad . \quad . \quad (7)$$

which is the relation between the applied pressure difference p in inches of water and the corresponding displacement h of the meniscus.

The magnification is obviously equal to the reciprocal of the term in square brackets on the right-hand side of (7), and from this it is evident that, for a manometer of given dimensions, the more nearly equal the specific gravities of the two

liquids used, the greater will be the magnification. Unfortunately, in practice the magnification that can be usefully employed cannot be increased indefinitely without introducing serious disadvantages and causes of inaccuracy. If σ_1 and σ_2 differ only by a small amount (5 per cent. or less) the instrument must have long tubes in order to give readings over a reasonable range of pressure, and the movement will be sluggish. Moreover, when the densities are too nearly equal, trouble is experienced with the meniscus, which becomes irregular in form and tends to break up. It is not advisable to aim at a magnification greater than 10 or 12 to 1, under which conditions the gauge should prove fairly satisfactory. A further factor which sensibly influences the performance of the instrument is the bore of the tubing, which should not be so large that the shape of the meniscus is under insufficient capillary control, nor so small that the capillarity forces are excessive, in which case the liquid column will break if the pressure difference applied to the instrument is subject to rapid changes or fluctuations.

The choice of suitable liquids is also a matter of some importance. As stated above, the primary requirements are that they should neither mix nor be soluble in one another. It is desirable also that the meniscus should be of definite shape and that the liquids should not adhere strongly to the walls of the tube when the surface of separation moves. Since, moreover, the indications of the instrument are dependent upon the densities of the two liquids, the latter should as far as possible be chosen with low and approximately equal coefficients of thermal expansion, so that the calibration does not alter appreciably with temperature fluctuations. Finally, volatile liquids should preferably not be employed, since their use leads to progressive zero changes as evaporation of one or both of the liquids occurs.

Various liquids have been used in gauges of this type, but none has been found to give entire satisfaction. The author has obtained good results with a gauge having a magnification of 10 to 1 in which benzyl alcohol and an aqueous solution of calcium chloride were used, the former liquid being coloured by the addition of a small quantity of aniline black, soluble in oil, in order to throw into greater prominence the surface of separation of the two otherwise colourless liquids. A number of instruments of this type using these liquids are in use and are proving fairly satisfactory. The advantage of using a liquid such as calcium chloride solution is that its specific gravity can be varied by the amount of the solid salt added, so that when used in conjunction with a liquid of definite specific gravity (in this case benzyl alcohol) different

degrees of magnification can be secured. In the gauge under consideration, the specific gravity of the alcohol was 1·048, and that of the heavier calcium chloride solution was adjusted to give a magnification of 10. The variation in the calibration of the instrument with temperature was found to be about 3 per cent. for a temperature range of 12° C., the magnification being higher by this amount at the lower temperature. Errors due to this cause can to a large extent be eliminated by immersing the gauge in an outer vessel containing water, whose temperature is always adjusted to a convenient constant value (probably 65° F.) before readings are taken. An alternative and perhaps easier course is to apply corrections determined by calibrating the gauge at different temperatures. Since the coefficients of thermal expansion of the liquids will be, to a first order, linear, it is sufficiently accurate to assume a linear variation for calibration with temperature. Adequate information for the determination of the correction factor for any temperature will, therefore, in general be obtained by calibrating the gauge at two temperatures, which should preferably be chosen at the extreme ends of the range to which the instrument is likely to be subjected.

Before the liquids are introduced into the manometer it is advisable to shake them well up together in a large flask and to allow them to separate out. Each should then be filtered in order to remove small bubbles of the other and poured separately into its appropriate reservoir. In this manner each of the two liquids is saturated with the other before being introduced into the gauge glass, so that no subsequent changes of density (and hence of calibration) are likely to occur from diffusion and interchanges of water content at the common surface. In addition to this precaution it is essential—and the importance of this point cannot be overemphasised—for the glass-work to be thoroughly chemically clean before the liquids are introduced. The slightest trace of grease on the interior of the inner tube will spoil the definition of the meniscus, and cause difficulty in reading its exact height. The improvement in the working of the manometer and in the appearance of the meniscus after a dirty instrument has been thoroughly cleaned is remarkable. Cleaning is best effected by means of strong nitric acid and alcohol, or strong sulphuric acid and potassium bichromate.* The reagents should then be removed by washing with distilled water and pure alcohol; the final drying may be accelerated by blowing warm air through the glass-work.

* Nitric acid and alcohol are probably the best cleansing agents, but they must be applied cautiously to avoid damage to the glass-work due to too vigorous reaction.

The following internal dimensions are recommended for the various elements of a gauge of this type :—

Diameter of outer reservoir . .	3·5 inches.
Diameter of inner reservoir . .	2·5 ,,
Diameter of outer tube . . .	0·5 inch.
Diameter of central tube . . .	0·2 ,,

The length of the tubes will naturally be determined by the range of pressure that the gauge is intended to cover. With a magnification of 10, a length of about 24 inches should be sufficient, corresponding with a maximum pressure reading of about 2·3 inches of water, allowing for the necessity of obtaining a zero reading slightly below the top of the inner tube. For pressures greater than this, sufficient accuracy will probably usually be obtained, by the use of an ordinary U-tube water manometer. For strength, it is advisable to weld the bottom of the inner tube to the outer tube, and to make provision for the flow of liquid by piercing about four holes in the walls of the inner tube at its lower end. The total area of the holes should be equal to the area of the inner tube. A scale of inches and tenths, or preferably of millimetres, should be engraved on the inner tube for observing the position of the meniscus.

In a more simply constructed but somewhat less reliable form of this gauge, illustrated in Fig. 60, the two reservoirs and the tubes leading from them are arranged side by side instead of concentrically. In this case care must be taken not to tilt the instrument whilst observations are in progress, as appreciable movements of the meniscus will be caused by comparatively small inclinations of the instrument. The formulæ derived for the type with concentric tubes apply, without alteration, to this gauge.

THE Wonder Hour, which was introduced to the nation's radio audience on Sunday September 27 over the National Broadcasting System's Red Network, marked the beginning of the second series of fall programs sponsored by the Minneapolis-Honeywell Regulator Company. (It will be remembered that this company sponsored the outstanding radio concerts by the Minneapolis Symphony Orchestra last fall over one of the large networks.) This program, which was the first of a series of thirteen weekly Sunday afternoon broadcasts, commencing at 3:30 eastern standard time, is dedicated to the wonders which modern engineering has accomplished in automatic control of heat, cold and pressure. A specially selected orchestra from the National Broadcasting Studios has been chosen, under the direction of Leroy Shields, musical director of the National Broadcasting Studios in Chicago. Ruth Lyon, one of America's greatest sopranos, and Charles Sears, tenor, will be the regular artists on this program.

In commenting on this fall radio campaign, Mr. C. B. Sweatt, vice President in charge of sales of the Minneapolis-Honeywell Regulator Company, said "The Wonder Hour, which pays tribute to the accomplishments in the fields of automatic control of industrial processes, should be of unusual interest to the readers of *Instruments*.

"As perhaps never before, the scientific advancements in automatic control in the countless fields of industrial uses are brought before the attention of the great American public. This broad interpretation, which is indicative of our confidence in the future, should be of tangible benefit to all of these industries in which automatic control of heat, cold, or pressure is an important factor," concluded Mr. Sweatt.

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

The Principles and Practice of Geophysical Prospecting. By *A. B. Broughton Edge and T. H. Laby.* The Macmillan Company, New York, 1931. Cloth, 8¾ x 11¼ inches, 380 pages. Price $5.00.

This book is the very complete final report of the Imperial Geophysical Experimental Survey. The report covers 18 months of experimental geophysical surveying, all in Australia, carried out at a cost of about $150,000. The purpose of the work was to test and compare various geophysical methods to determine their practical value.

Most of the work was done over areas of known geology, and in many cases more than one geophysical method was applied to the same area. Experimental surveys were made by electrical, magnetic, and gravitational methods, and later by the seismic method. The report covers in detail the description and operation of the instruments used, field procedure, interpretation, and value of the final results. The technical discussion of the various methods is separately assembled in Part II of the book (126 pages). Some cost data on various methods are included in thispart.

The report is particularly complete on the electrical methods, this having been done deliberately according to the director of the survey because the published literature on these methods is less complete than on the other geophysical methods. The division of page space among the various methods, including both Part I and Part II is as follows:—Electrical 185, Gravimetric 74, Magnetic 24, Seismic 62. Many maps, profiles and cross-sections are given and the geological significance of the geophysical field data is carefully considered. In the treatment of the electrical methods, particular attention is given to the possibilities and limitations of various methods of operation and to the choice of the probably most useful method for a given problem.

The experiments with the gravimetric method are perhaps the least satisfactory, due to the use of a comparatively rare type of equipment which is apparently not as well adapted to field work as the more commonly used instruments. The seismic method was not included in the original program, but was added a year after the work started. It is therefore represented by field experience over a much shorter time than the other methods. Many of the conclusions relative to this method are based on modifications and methods of operation which were suggested by the short field experience, but could not be carried out in the limited time available.

The book is certainly the most complete one in English on geophysical prospecting in general. It probably contains more information on actual field practice and experience than all previously published geophysical literature in English. The possibilities and limitations of the various methods are carefully presented and the value of the information each gives is estimated without bias. In this way, it is very different from much of the geophysical literature which deals with only one method and often points out only its possibilities without considering its limitations. The report should serve as a useful guide to anyone faced with the decision as to which of the various geophysical methods should be applied to a given problem. It can be recommended as a most useful general reference work on geophysical prospecting and will probably soon be in the library of most thoughtful geophysicists.—L. L. Nettleton

Les Origines Du Système Métrique. *By Adrien Favre.* Les Presses Universitaires de France, Paris, 1931. Paper, 5¾x9 inches, 240 pages

In this well-printed work, Professor Favre has given us the story of the metric system in a form that meets a "long-felt want" in that it tells of the earlier attempts at reform of weights and measures in France with a wealth of quotations from official documents that renders the information invaluable from an historical point of view.

Professor Favre proves clearly that the metric system was evolved under the Royal Government long before the revolution and its promulgation by the Republican Assembly was a mere accident arising out of delays due to long drawn out negotiations for its acceptance by other countries, especially by England.

He gives a very full account of these parleys with England but curiously enough makes no mention of any letter from James Watt, to whom we are apt to give the credit of suggesting a "philosophical system." On the other hand he gives great prominence to the work of Sir John Riggs Miller, M. P. who apparently brought in a Bill on the 14th July, 1789, for a new system based upon the length of a seconds pendulum. Both English and French scientists had made elaborate experiments on the exact length of such a pendulum as would beat exact seconds in a vacuum. Talleyrand had long corresponded on the subject with Sir John, whose influence he acknowledges as having led the French Government to introduce a similar Bill, with the concurrence of King Louis XVI who promised to write to the English King. Matters had arrived at this happy stage when suddenly all hope of international agreement on the subject was shattered by the King's flight to Varennes, his re-capture and execution.

These events did not, however, arrest the movement in France, for in 1789 the metric system was formally adopted by law altho the meter had still to be made. The seconds pendulum was abandoned, as it had only been accepted in order to please the English and the meridian or its ten millionth part became the basis of the new system. Delambre and Mechain were still struggling with the measurement of the meridian Dunquerque-Barcelona, but their work was much delayed by a rumour spread among the peasants to the effect that they were making a survey of land values in view of a land tax. This led to their survey pegs being torn up unless constantly guarded, while every village mayor demanded to see their papers and harassed them in every way. In despair, the Government adopted a "provisional meter" based on measurements made in 1740. For all commercial purposes it was quite accurate enough, differing from the present meter by less than 1/3,000.

The historical part of Professor Favre's book strikingly illustrates the futility of trying to ascertain ultimate origins, as he traces the essential features of the metric system, decimal division and inter-relation of weight and length to a much earlier date. In Lorraine the Toise had long been divided into 10 feet of 10 inches of 10 lines, while the Encyclopaedists (1754) had advocated decimal divisions for all weights and measures, and Condorcet suggested the use of a cubic measure of water for linking up weight with length, but disclaimed originality as "the idea was common amongst men of science" in his day. Careful measurements had been made for the purpose by Dupuy who carefully compared river water with distilled water.

Favre also gives an interesting account of conflicts between the business men and the pure science members of the Academy concerning names for the new measures. In the first law, the business men gained a victory in regard to the weights, which were to be named "Bar" of 1,000 kg., "Graves" (1 kg.), and "Gravets" (1 gram), while the cubic measures were to be the "Cade" (1 cubic meter) and the "Pinte" (1 liter). Finally, however, the pure science men gained the day and gave us the Greek and Latin prefixes used to-day in the metric system.

The final chapter of Favre's book tells of the struggle to bring in England as a partner in the reform.

When this invaluable Metric History comes to be translated, it should have an index and it should also have the republican dates explained by a little bracketed Gregorian date. French readers can use a book without index and are also supposed to know the meaning of a date such as "5 Thermidor l'an VIII" but an English reader has to use a pencil and much thought under such difficulties. What a pity it is that such books need translation and printing in many languages. Newton's Principia, being published in dog Latin, flashed over Europe in a year, Molinari's Chemistry was not done into English until the eve of its second edition.—E. C. Barton.

NEW INSTRUMENTS

Recently Developed by Instrument Manufacturers

Write Information Section, Instruments Publishing Co., Pittsburgh, Pa., for additional Information.

Split-Core Current Measuring Set

(Rubicon Company)

THIS set was designed for the accurate measurement of alternating currents flowing in conductors, cables and busbars, without the necessity of opening the circuit to insert an ammeter. The set may be used in any application involving the measurement of alternating currents of commercial frequency. It is particularly useful for testing the load on motors, transformers, electric furnaces and similar apparatus and for checking the balance in polyphase systems, without in any way interfering with the service.

The set consists of 2 units: the transformer and the meter. These are permanently joined to each other by a 6 foot, 3 conductor rubber-covered flexible cable. When not in use the transformer fits in a compartment of the meter box which is made of high grade hardwood and is supplied with lid and carrying strap. Two ranges are provided: 0-40 amps. and 0-200 amps. Changing from one range to the other is effected by means of a switch located near the meter. The set measures 9¼x7¾x5¼ inches and weighs but 7 pounds.

A feature of this set is the provision for the safety and the convenience of its operation. Each transformer is supplied with a pair of well insulated grip handles. Due to the leverage which these handles afford, only one hand need be used in the manipulation of the transformer. This not only affords greater immunity from electric shock, but also makes it possible to use the instrument in out-of-the-way places and where space is limited.

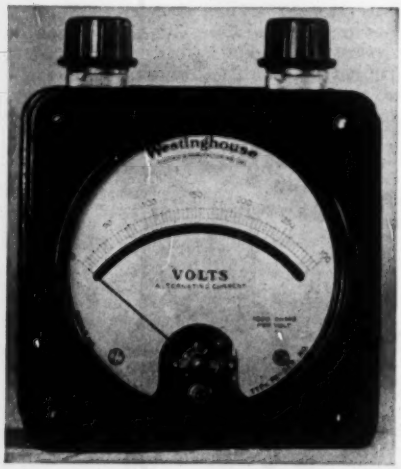
Each meter is hand calibrated with its transformer and leads as a unit. This results in the highest accuracy which it is possible to obtain with the split-core construction. The guaranteed accuracy is 2% of full range on either range, although the actual accuracy of calibration is much higher

New A-C Instruments

A NEW instrument, consisting of a copper oxide rectifier and d'Arsonval D.C. galvanometer, has been developed by the Westinghouse Electric and Manufacturing Company as an addition to their line of A.C. instruments. In this new instrument, the alternating current is first rectified, and then indicated by the instrument proper. The use of the d'Arsonval movement, in which a strong field, permanently established by the magnet, enables a moving coil with a very weak field of its own to develop a high torque, effects a high sensitivity with very low internal energy consumption.

It is the development of the copper oxide rectifier that has made possible the manufacture of a rectifier type instrument for general use. Previous to its development, rectifier instruments were complicated apparatus, unpractical under other than laboratory conditions.

This new type of instrument differs in principle from the usual A.C. instruments in that the torque and deflection are proportional directly to the current, rather than to its square; and, therefore, the rectifier instrument measures according to the average value and not the root mean square value of the A.C. wave. However, the scale is usually calibrated to read the root mean square value of a pure sine wave; and changes of wave form effect an error.



Consequently, since such instruments read correctly only on a pure sine wave, their application is limited to cases where the wave form is either a sine or of a known form for which a correction can be applied to the readings. This limitation necessitates the recommendation of these instruments only for applications where the usual type A.C. instruments are inapplicable due to the amount of energy they consume. On a 60 cycle circuit of good wave form, and at room temperatures, rectifier instruments can be depended upon for an overall accuracy of 3% or better under conditions for which they are suitable.

The readings of rectifier instruments are quite free from frequency errors, the reading decreasing only ½% per kilocycle. Commercial instruments are calibrated at 60 cycles, and show ½% frequency error at 1000 cycles, 5% error at 10,000 cycles, etc. up to 35,000 cycles where different conditions may prevail. Temperature errors are practically negligible at ordinary room temperatures.

Rectifier instruments are available as voltmeters in ranges from 4 volts up, at 1000 ohms per volt. A satisfactory 3 volt range can be made with a resistance of 2000 ohms per volt, and by sacrificing temperature coefficient, ranges of 2½, 2 or even 1½ volts can be obtained with some of the more sensitive instrument types. While the lower resistance rectifier voltmeters can be produced, there is no need for them because the field for such instruments is satisfactorily covered by other types.

Milliammeters are available from ½ to 20 milliamperes. Above 20 milliamperes the use of some other type of A.C. instrument is recommended.

The application of the rectifier voltmeter should be confined to circuits requiring a high resistance voltmeter of at least 1½ and preferably 3 or 4 volts full scale.

Some of the uses of the rectifier instrument include the following: Output meters for use with vacuum tube oscillators, signal strength indicators, A.C. output of low power generators A.C. output of vacuum tube devices, A.C. galvanometers for impedance bridges, etc., mutual conductance indicators, measurement of volt-ampere of A.C. coils, railway signal testing, resonance indicator for wave meters, measurements of radio-field strength, oscillators for radio service testing, power level indicators, sound measurement indicators, A.C. micro-ammeters in general, high resistance A.C. voltmeters in general and core loss or flux voltmeters.

Smoke Indicator

(*Sales Corporation*)

THE SMOKOMETER is a simple form of smoke indicator and comprises a projector mounted on side of a gas passage, uptake, flue or stack and an indicator mounted on the opposite side as illustrated in Fig. 1. The projector throws a beam of light across the passage which falls on the central portion of the indicator.

Smoke particles in the gases cause shadows to fall on the central screen the intensity of the shadows varying with the density of the particles. Around this central screen there are illuminated segments graduated in the Ringelmann scale of smoke densities. The top portion or segment is clear the others corresponding to Ringelmann scales numbers, 1, 2, 3 and 4. The operator has a continuous indication of the smoke made and an adjacent comparison scale.

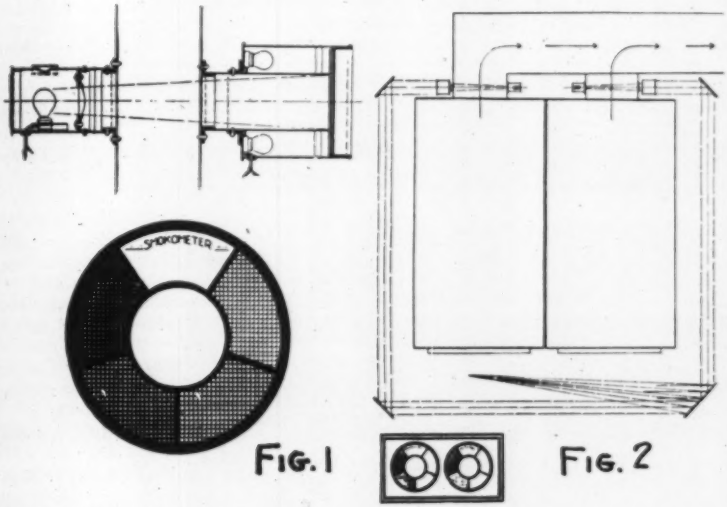


FIG. 1 FIG. 2

The instrument is provided with cast iron mounting flanges and may be mounted in various ways. If the flue or stack is visible from firing alley it may be mounted for direct observation. In cases where direct observation is not possible plain mirrors may be used to reflect images of the instrument to any desired point. In Fig. 2 are shown 2 instruments mounted on boiler uptakes with mirrors to reflect images to firing aisle. The bottom figure shows the images of both instruments as they would appear in right mirror from the point indicated.

It is to be noted that this is not a periscopic type instrument in which light is reflected and the shadow screen placed near observer. The image is formed complete in instrument and only plain open mirrors used to reflect this image. This makes it possible to reflect the image to various points, as for instance to a mirror in fire room and one in engine room or chief engineer's office.

The instrument can also be used as a sampling type one in which the instrument is mounted at any desired point and samples of the flue gases passed through it. For this purpose a cast iron smoke box with inlet and outlet openings is substituted for the smoke passage and the gas drawn through this box by means of an aspirator. One aspirator may serve a number of instruments mounted on common panel board or served by the same exhaust duct. The same gas may be passed through 2 instruments indicating at 2 points if desired.

With large installations the instrument may be placed on boiler control panels so that it can be observed as fuel and air adjustments are made. In oil burning plants where one attendant serves a battery of boilers the instruments may be mounted on a common panel board for continuous observation with others at boiler controls if desired.

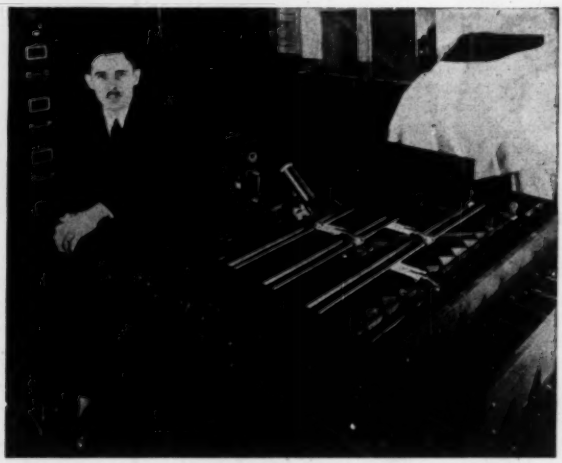
The instrument is furnished in two sizes. One has a 6″ illuminated dial; the other a 12″ dial.

Machine Used to Classify Lighting Company Bills

(*Westinghouse Elec. & Mfg. Co.*)

DEVELOPED and designed by Douglass A. Young, an engineer located at the Newark Works of the Westinghouse Company, this ingenious machine not only reads cards, but places them in any of the 100 compartments in the machine where they belong without any human hand touching them. The machine which is operated by a single "electric eye" or photo-electric tube, resembles in appearance a miniature railroad switching terminal with the card being routed over its proper track after the "electric eye" has scanned the card and set the machine in order that the card may be delivered to its proper destination.

The development of this latest electrical and mechanical device is the result of a request from an executive of a large corporation, to solve a difficult problem that has been confronting this, as well as many other companies for many years. This particular company like many others throughout the country, sends bills to its customers every month. Part of the bill (the stub) is returned to the company by the customer with his remittance. The classification of this stub, which is returned at the rate of many thousand per day throughout the month, upset the entire organization as it is almost impossible to keep help on this tedious and monotonous grind of sorting and filing the returned remittance stubs. Therefore, the company called upon the resources of the Westinghouse Research and Engineering organization to develop a machine that would eliminate this problem, with the result that this new sorting machine was produced.



Operation of the newest robot is so simple that it requires the services of only one person. When the names and addresses are stenciled on the bills, a number is printed also. This number guides the sorters in the classifying of the stub when it is returned. With the new sorting machine, this same principle is carried out, only a simple printed code is substituted for the numbers. By this system of code, according to Mr. Young, it is possible to get over one hundred million combinations of numbers on a card 1¼ inches wide by 3¼ inches long and still have enough room for the name and address of the customer.

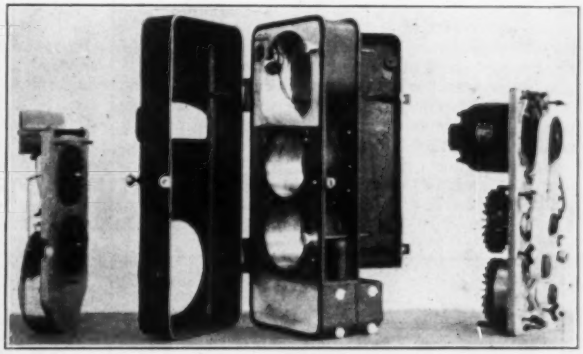
When the operator is ready to start sorting, after turning on the power, he places a stack of cards in the feeding receptacle of the machine. A weight is then placed on the top of the cards which puts pressure on the card at the bottom of the pack. This lower card is then picked up by an ingenious device covered by live rubber, which operates effectively even with badly mutilated cards. Incidentally, many cards come back badly torn and rumpled and the machine must handle these as well as more perfect cards. The rubber covered device frees the lower card from the cards above, and then pushes it forward under the gaze of the "electric eye" which is focused on a spot which the card must pass over, and therefore the coded number is read before the card is routed to its proper place. The reading of this card by the "electric eye," which in turn operates the various relays, is done in the fraction of a second that the card passes under its gaze. The card passes under a light beam and the light is reflected by the light surface of the card and interrupted by the code lines. These signals are transmitted by the "electric eye" to the relays and trip switches and cause a mechanical hand to respond ready to take the classified card to its proper place in any of the 100 compartments in the machine

New Gas Specific Gravity Meter

(Permutit Company)

THE well established Ranarex principle has been retained in this new specific gravity indicator and recorder but the design has been simplified and the machine made more compact and rugged. All working parts are easily accessible. The indicating and recording mechanism is attached to one plate and the driving mechanism, including the motor, to another. Both plates may be removed without the use of tools by loosening a few wing screws. This represents an improvement over the old design, wherein tools were required for removing the bearings and motor.

The humidifier is an integral part of the machines and the passages connecting the humidifier compartments and the measuring chambers are cast into the body and rear chamber door. This eliminates the pipes connecting the humidifier and measuring chambers used on the older model machine. Upon removing the rear chamber door, all gas channels are opened for inspection over their entire length.



Bakelite impellers, impulse wheels, separating plate, etc., are used on the new machine to replace similar parts of cast aluminum on the old model. The machine is enclosed in a dust-proof cast aluminum housing and is not affected by heat, moisture or shock. It is available for wall or flush panel mounting.

The standard scale on the new model machine is graduated from 0.2 to 1.0 (air = 1.0) specific gravity in place of the 0.35 to 1.0 range on the strip chart model. This scale range has been found satisfactory for most manufactured and natural gases. The accuracy of the machine is guaranteed within 0.015 specific gravity. The scale is 9″ wide and the circular charts are 8″ in diameter. The recording mechanism on the new model is driven either by a spring driven clock or an electric clock where alternating current is available. These chart movements replace the friction chart drive of the strip chart model.

In most instances the time lag will be less than ½ minute. This is of great importance to the engineer.

A special Ranarex recorder for the control of butane-air mixing has been developed. This machine has a specific gravity range of 1.0 to 1.2 and a superimposed adjustable scale graduated in Btu per cubic foot, corresponding to the heating value of the butane-air mixtures, thus giving both readings on the same machine. Other scale ranges are available for special applications where the specific gravity of a gas mixture is a guide to efficiency and satisfactory operation.

Arthur Kendrick, president of the International Equipment Company, former assistant professor of physics at Worcester Polytechnic Institute, died in Newton, Mass., on September 24th in his 66th year.

Mr. Kendrick was born in Nashua, N. H., and attended Amherst College from which he was graduated with an A.B. degree in 1887 from Harvard. In addition to his association with the Worcester institute, he taught physics at Leicester Academy and the Rose Polytechnic Institute in Indiana, where he was associate professor.

In 1901 Mr. Kendrick organized the International Instrument Company, later known as the International Equipment Company, of which he was president.

Route Surveying Instrument

(*Gustav Heyde*)

THE instrument illustrated in Fig. 1 and shown in section in Fig. 2 is designed to simplify the tedious process of route-surveying which, as is known, consists in recording continuously readings of watch and compass. The instrument is most suitably carried on a strap in front. It is operated so that, in the direction of walking, the *white* double-line (direction indicator) at each noticeable deviation of the latter is adjusted over the (white inserted) *north* end of the needle (3) on the compass cover glass (1) by rotating the rim of the cover glass (2). By this rotation the pencil (4) is guided along a screw-spindle (5) arranged in the compass case so that any position of the compass needle corresponds to a definite position of the pencil. This position is marked on a drum (6) also mounted in the case on which millimeter paper is fastened; the drum revolves uniformly by means of a clock around in axis (7) which is parallel to the pencil spindle (5). Since the pencil remains permanently in contact with the paper on the drum during the walking the lengths (s) drawn by the pencil in the direction of the rotation of the drum represent the paths passed over under a definite azimuth; the clock work is adjusted in such manner that a deflection of 1 mm of the pencil in the direction of the rotation of the drum corresponds to a walking time of 5 min. so that the latter can be read to about ½ minute by estimating 1/10 mm. In adjusting the change in *direction* of walking by the beforementioned turning of the cover glass the pencil records every time a line (w) parallel to the axis of the drum the length of which corresponds to the *change of direction* in degrees. The grade of the spindle (5) moving the pencil is dimensioned so that a deflection of 1 mm of the pencil in direction of the axis of the drum corresponds to a change of direction of 10° so that, again by estimating 1/10 mm, the change of direction can be read to about 1 degree. It is practical to number the millimeter lines running in the direction of rotation of the drum from 0° to 360°, from 10 to 10 degrees so that the compass azimuths corresponding to the individual paths can be read directly on the paper strip.

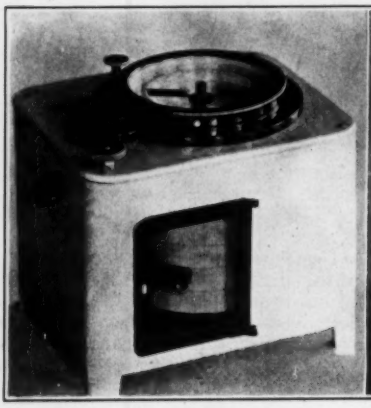


Fig. 1

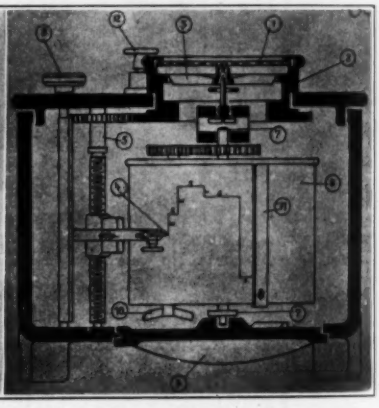


Fig. 2

If the walk is interrupted the pencil must be lifted from the drum by turning the knob (8) and at starting the walk again, it must again be brought into contact by turning the knob back. If the clock which runs 18 hours is to be wound the pencil must be lifted and the lid (9) at the bottom of the box to be removed by giving it a quarter turn. Then the drum is taken out of the box after having unscrewed the lower screw (7) and the wing nut (10) is turned until one feels a resistance. After removal of the holder (11) the used paper strip can now be removed and a new strip mounted on the drum in obvious manner. The drum is replaced in the box whereby the projection—in the right upper part of the window section—must be moved back so that the drum is seated properly. Care must also be taken that the pencil point is not broken. Then the lid (9) is put on and fastened by a quarter of a turn.

The compass needle can be arrested by turning knob (12). Direction indicator, north end of the needle and also the numbers of the circle are painted with a luminescent radium paint which makes it possible to use the instrument at night.

Portable Gas Analyser

(Charles Engelhard, Inc.)

THE PRINCIPLE of thermal conductivity for the continuous analysis of industrial plant gases has been used throughout industry for many years. But most thermal conductivity analysers are calibrated to read directly in percentage of gas analysed and for this reason are limited to the measurement of one gas. For example, an instrument calibrated to measure NH_3 in H_2N_2 could not be switched over to measure SO_2 in air without lengthy recalibration. The Engelhard "Gasalyser" however is provided with a double range scale calibrated in millivolts. The upper scale is divided 0-5 and the lower 0-50. Each instrument is provided with a chart showing the relation between millivolt output and the different gas percentages. The measurement of a gas simply resolves, then, into passing a sample through the "Gasalyser" and reading the millivolt deflection. Reference to the proper curve on the chart gives the gas percentage. It can measure acetone, butane, carbon dioxide, carbon monoxide, hydrogen, helium, methyl alcohol, ammonia, sulphur dioxide in air; NH_3 in H_2N_2; O_2 in H_2; H_2 in steam; carbon dioxide in a mixture of hydrogen, methane, carbon monoxide, nitrogen and carbon dioxide.

For temperature determination, any type themocouple developing 0-50 millivolts may be used.

Sir Howard Grubb, noted authority on astronomical instruments, died in Dublin, Ireland, September 16th.

He had sometimes been credited with the invention of the submarine periscope and made many developments on it. It was he who suggested the construction of a movable floor for the telescope at the Lick Observatory and was responsible for many other important telescopic devices. He was astronomical instrument maker and contractor to the British Government and to colonial and foreign governments.

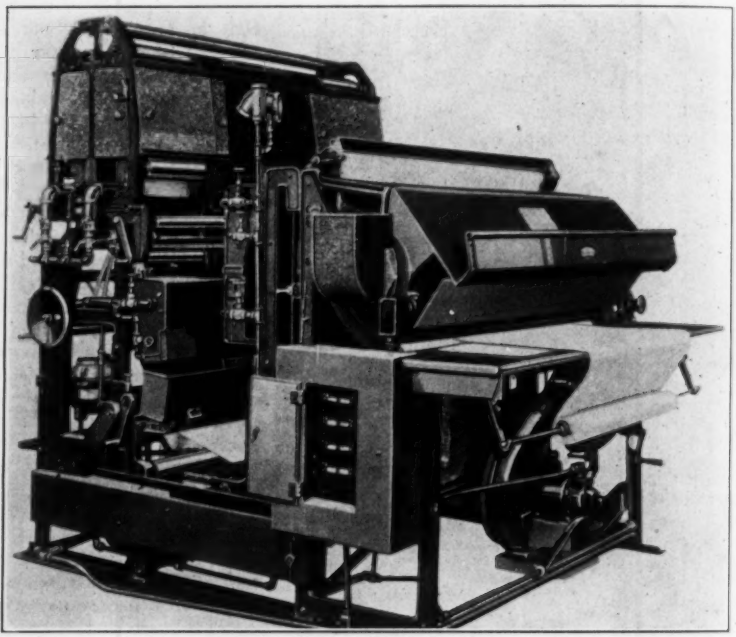
Continuous Blue-Printing Equipment

(C. F. Pease Co.)

THE new "Peerless" Model "25" continuous blue-printing equipment was particularly designed to meet both the demands of the moderate budget for blue-printing equipment and the requirements for high quality prints at the same time.

The complete equipment is composed of 3 units—the blue-printing machine, the washing machine, and the potashing, washing, and drying machine.

The blue-printing machine can be operated independently from the washing, potashing and drying equipment by means of a simple clutch adjustment. All units are made in two sizes, 42″ and 54″ wide and the machines can be wired to operate on 220 volts either D.C. or A.C. The 42″ machine is equipped with 6 lamps and the 54″ machine with 7 lamps. Each lamp consumes 6½ amperes on D.C. and 7½ amperes on A.C. but this amperage can be increased if faster printing speed is required.



As with all machines, when operating continuously tracings and paper are laid face up on a continuous roll of paper feeding in at the front of the machine. They are carried upward around the contact glass, past a glowing bank of arc lamps. All lamps are mounted in horizontal alignment to give uniform light distribution and fast printing speed with full effect of all valuable printing light rays.

After the exposure has been made, tracings are automatically returned into the tray at the front of machine near the operator's hands while the prints on the continuous roll of paper are carried through the machine and the subsequent operations of washing, potashing, and drying. When making single prints both the tracing and the paper are returned into the tray at the front of the machine and prints can then be individually washed and dried by means of a separate sheet washer and sheet dryer.

Overall dimensions of the Model "25"42″ blue-printing machine are 5′ 11″ wide x 2′ 11¼″ x5′7.″ Overall dimensions of the 54″ blue-printing machine are 6′11″ wide x2″11¼″x5′7″. Overall dimensions of the 42″ complete blue-printing equipment with gas heater are 5′11″ wide x7′9¾″x7′3,″ and with electric heater are 6′1½″ wide x7′9¾″x7′3.″ Overall dimensions of the 54″ complete blue-printing equipment with gas heater are 6′11″wide x7′9¾″x7′3″ and with electr ic heater are 7′1½″ wide x7′9¾″x7′3″.

Vacuum Contact Mounting

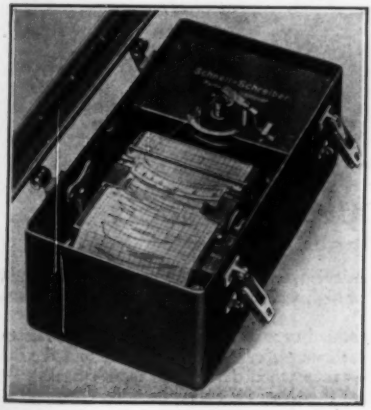
TO facilitate the application of the Burgess Vacuum Contact to relays and other actuating mechanisms, a conveniently mounted unit has been developed by the Burgess Battery Company. The unit consists of a C-shaped metal casing to protect the glass vacuum contact held in a pair of clips, a connecting link for coupling the actuating mechanism to the extension stem of the vacuum contact, and a pair of screw binding posts. An adjustment screw with lock nut permits of applying counter pressure to the connecting link in offsetting the inherent spring tension that normally keeps the vacuum contact close, when operating as an open circuit device. By rotating the vacuum contact one-half turn in its spring clips, it may be operated as a closed circuit device after adjusting the connecting link.

The vacuum contact mounting is especially applicable to the standard type telephone relay. It may also be applied to any mechanical, manual or thermostatic form of actuation. An actuating force of 6 to 10 ounces, with a movement of but .02 inch, is sufficient to operate the vacuum contact which in turn controls up to 6 amperes continuously or 8 amperes intermittently, at potentials up to 220 volts. The vacuum contact has innumerable possibilities in controlling power circuits by means of the most delicate actuating force. In the present mounting its application is reduced to simplest terms.

Rapid Recorder

(Pyrometer Instrument Company)

RECORDING instruments, especially those used for recording of temperatures, generally operate on a principle which does not permit registering quick changes, as is the case in the point by-point method where the deflection of the needle is recorded every few seconds; and change in between this period will thus not be known. This is a great draw-back if quick operations of furnace doors, passing hot billets, etc. must be recorded. On the other hand, the use of an oscillograph which is able to record all these quick phenomena is too costly and unhandy in the shop as the records must be developed photographically.



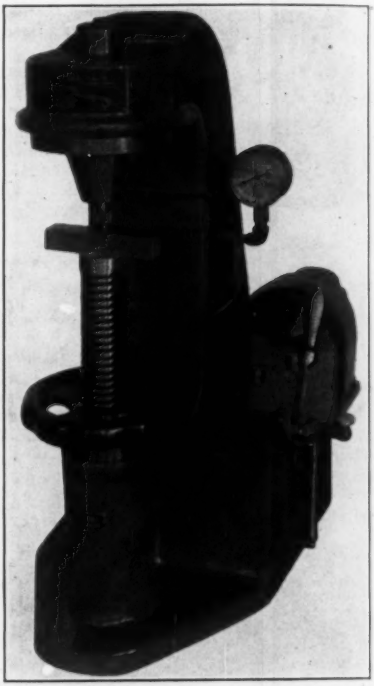
Below is described a new rapid recorder, which is intended to fill the gap between the two above named types of instruments and to furnish a simple, sufficiently sensitive and rugged apparatus. It consists of a highly sensitive moving coil system with a short period of natural oscillation on a vertical axis; it is arranged for connection to a thermocouple or radiation pyrometers, or it has a cross-coil moving system for connection to a resistance thermometer. The resistance of the moving coil is 20 ohms, the total deflection corresponds to 30 millivolts. The axis of the moving system carries, instead of a metal pointer, an angular forked holder on which a thin glass capillary rests which serves as a pointer; its one end at the axis of the system is bent downward into a little vessel containing a colored ink; the other end, somewhat lower, corresponds to the pointer and rests on the horizontal paper chart with a pressure of only 22 milligrams. The ink rises by capillary action from the vessel into the glass tube and passes through it to the point over to the chart and would in this manner trace a continuous curve. The friction of the pointer on the paper is still too great, in spite of the very light pressure of the point, for the small torque exercised by the moving system so that the pointer cannot move freely. The free movement, however, is achieved in this construction by a small hammer which is operated by an electric circuit-breaker and hits the paper under the pointer about 50 times per

second so that a slightly jumping motion is imparted to the point. The friction is reduced to a minimum in this way. As the pointer is supported horizontally and the impacts of the hammer are vertical from below the moving system of the instrument is not influenced and the accuracy of the instrument does not suffer.

The chart has a width of 120 mm. and advances 0.07 mm. per sec. or 240 mm. per hour. It is moved by a clock which, at the same time also operates the small hammer. This hammer arrangement requires about 2 volts which can be supplied by a bell transformer. The chart can be renewed after taking off the capillary and unlocking the table; this movement stops the clock and simultaneously opens the electric circuit. The whole instrument is encased in a strong cast aluminum box; the lid is made dust- and water-proof by a rubber gasket.

Motor Driven Hardness Tester

(*Tinius Olsen Testing Machine Co.*)



THIS machine conforms to the general appearance of motor driven brinell machines which the Olsen Company have produced for a long while. The present model is unusually silent and fast in operation and with very smooth application of load. Provision is also made by the lever device on the side of the machine for operating by foot treadle if desired.

Foot operation is effected by adjusting a rod running downward from front of segment on lever at the right side of the machine.

All rotating parts are completely enclosed, and run in a bath of oil, thus assuring ample lubrication at all times, keeping the moving parts clean and reducing attention to a minimum.

Quartz Photoelectric Cell

(*G-M Laboratories, Inc.*)

THE quartz photoelectric cell was developed to meet the many requirements for a light measuring instrument of high sensitivity in the ultra-violet portion of the spectrum.

This cell is of the caesium oxide gas-filled type and has a clear fused quartz envelope in the region of the sensitive cathode plate. The cell is constructed so as to have extremely high electrical resistance when dark—that is, low leakage—due to the long glass beads surrounding the electrode support wires.

Among the many uses of the Type 1038-A cell may be mentioned the:

(1) Rapid and direct measurement of spectrum line intensities without recourse to photography.

(2) Measurement of ultra-violet light intensities in biological and therapeutic work.

The cell has an overall length of 6 inches.

Dynamic Balancing Machine

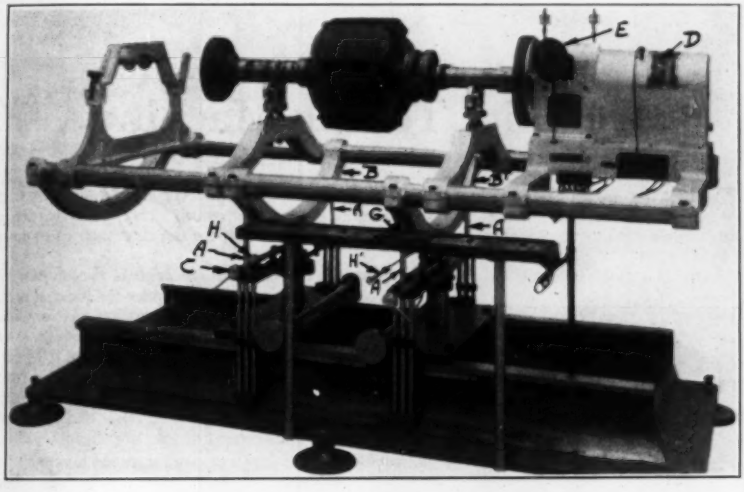
(*Tinius Olsen Testing Machine Co.*)

THIS machine as illustrated is capable of handling rotors weighing from 125 to 1,000 lbs. It is suitable for dynamically balancing Diesel engine crankshafts, electrical armatures, fans, turbine rotors, rolls, etc. Other standard sizes of this Style "S" machine will balance rotors weighing from 4 lbs. up to 15,000 lbs.

Balancing is done with unusual rapidity and extreme accuracy. The operator can see clearly the progress of balancing operation while machine is in motion which is a characteristic unusual in balancing machines, and aids materially in fast production with accuracy. The machine is very easy to operate, simple in construction and has a minimum of moving parts so that long accurate service is assured.

The amount of unbalance in rotor is determined by adjusting, while the machine is in motion, an artificial unbalance weight until it is exactly equal and opposite to the unbalance in rotor. Reading of the mount and angular position of this artificial unbalance weight then determines the amount and position of weight to be removed or added to the rotor to properly balance it. Two readings are taken, one at either end so that a corrective dynamic couple can be applied to the part being balanced.

The part being balanced in the illustration is an electric motor armature. It is supported on rollers attached to a light but stiff vibrating frame constructed of high test aluminum alloy cross members and tubular steel side rails.



At the right end on this vibrating frame is also located housing containing an adjustable artificial weight which rotates on shaft in line with the part being balanced. This weight can be adjusted to proper angular position and amount until it is exactly equal and opposite to the unbalance in part being balanced. The entire vibrating unit may be pivoted at either of the points B and B' by operating knurled knobs C and C' on front of the machine.

With the unbalanced part rotating, and artificial unbalance set to zero, the vibrating frame will oscillate horizontally supported on four vertical spring rods A.

The part being balanced is driven by motor on vibrating frame back of housing shown at right end of illustration.

When pivot B is engaged by means of knurled knob C, and pivot B' is disengaged by knurled knob C', the whole unit will oscillate horizontally around B as a center. Artificial unbalance weight is then adjusted—by means of four push buttons G while machine is in motion and without touching the vibrating unit—until oscillation or vibration ceases. This only requires a few moments and the machine is then stopped and the amount and angular position of unbalance in armature is indicated by noting the angular position and amount of artificial unbalance weight introduced which is clearly and definitely given in ounce inches by marks on the artificial weight at D.

The right hand pivot B' is then engaged by knurled knob C' and the left hand pivot B disengaged by knurled knob C and the part rotated by again starting the motor. Vibrating frame will oscillate until artificial weight in head D is again adjusted to proper angular position and amount opposite and equal to unbalance in the armature. Vibration or oscillation then ceases and the machine can then be stopped and reading taken of the amount and angular position of unbalance about B' as a pivot.

Since the artificial compensating weight is adjusted by the four push buttons on instrument board while the machine is in motion, the operator can note at all times the effect of this adjustable weight and very quickly bring it to the position desired to exactly compensate for the unbalance in armature.

Electric spark dial E indicates the angular position of unbalance in the armature and the angular position of artificial weight D. The spark will continue to show until the vibrating bed becomes stationary, at which time sparking ceases, correct balance exists, and readings are taken.

The two knurled knobs H and H' provide convenient adjustment to attain the highest degree of sensitiveness when required or to provide for quick readings where outside vibration might disturb the machine temporarily.

The main supports and pivots of the balancing frame may be placed in any desired longitudinal position with relation to the two planes of correction in the part being balanced.

After having established the desired axial position of the armature to be balanced with relation to pivots, the roller bearing brackets on which the part to be balanced rotates may be located in any convenient position on the balancing frame independent of position of pivots or spring support brackets without influencing readings taken from the machine.

Ductility Testing Machine

(*Tinius Olsen Testing Machine Co.*)

THE power is applied and load weighed hydraulically. The cupping tool operating mechanism is similar in general construction to the mechanism drive used on other Olsen Ductility Testing Machines. At all times during the test the depth of cup and a unit of load applied are indicated.

As the material is inserted and clamped in place the thickness of specimen is also shown by the graduated scale under the hand wheel.

A stop is provided so that the increase in load is automatically stopped for any desired depth of cup. Then the load can be instantly released so that it gradually and smoothly increases up to the specimen fracture at which time both the depth of cup and amount of load are shown.

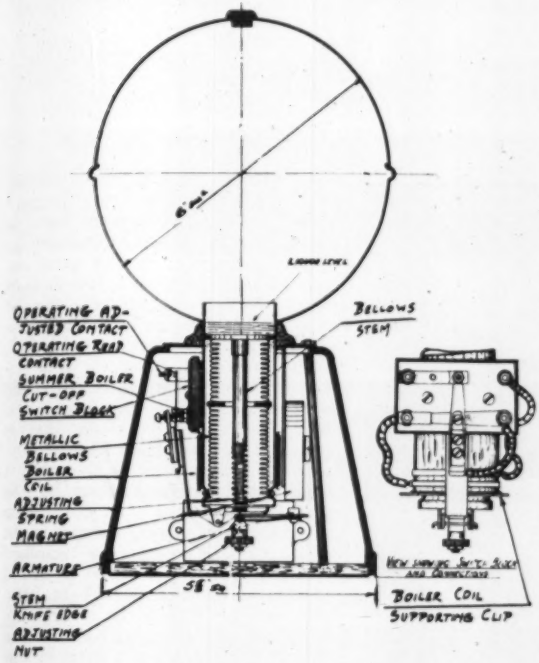
The depth of cup for initial load may be adjusted to any amount desired. For example, using the 1/16" thick specimen the machine can be set for 1/4" depth of cup by a device on front of the machine just under the hand wheel. When the cupping tool has produced 1/4" depth of cup in the specimen increase in load is automatically stopped and read on the large dial on front of the machine. By simply moving the small handle on the front of the machine under the hand wheel, the increase in load is again released and will continue up to the fracture point of the specimen. As soon as the pointer on large dial at front stops its forward motion and starts backward, it is evident that fracture has occured and the maximum pounds indicated by the dial pointer noted. The dial at top of the machine indicates the depth of cup under all loads and after fracture remains in this maximum position until the specimen is removed.

The motor and pump are stopped and started by the lever on top of the pump casing. Pressure is applied, released, or otherwise controlled by lever at front of pump housing.

New Radiation Thermostat

(*Electro Gas Development Co.*)

THIS instrument, which is more correctly described by the name "eupatheostat," differs from ordinary thermostats in that it controls the heating circuit in such a manner as to maintain *its own temperature* at a constant value, regardless of the fluctuations of the air temperature in the room.



A sectional elevation of the instrument is shown in Fig. 1. To the bottom of the thin copper sphere is attached a cylindrical sump, to the lower edge of which is fixed a copper bellows disposed inside the sump. No spring is used to oppose the expansion or contraction of the bellows, as the elasticity of the metal is adequate for the purpose. A central stem transmits the motion of the free end of the bellows to a pivoted lever, one end of which carries the contact spring of assembly, while the other end carries an armature in the field of a permanent magnet attached to the side of the sump, the purpose of which is to assure an equal make and break of the contacts. Round the lower portion of the sump is fixed a boiler coil, the supply for which is tapped off in the relay box where is also located the adjusting coil for regulating the load on the boiler coil.

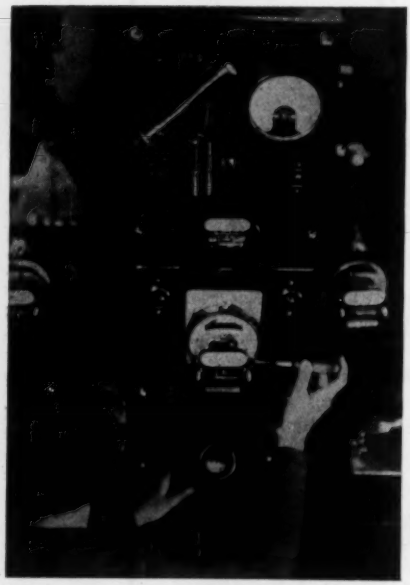
The sump is filled to the level shown in the figure with ethyl chloride, which is evaporated at a constant rate by the boiler coil, the vapor rising between the bellows and the sump into the sphere, where it condenses on the walls and drains back to the sump. The clearance between the bellows and sump is arranged so as to eliminate the hissing which would otherwise occur. As the rate of evaporation is constant, the vapor tension in the instrument is dependent solely upon the rate of heat loss by radiation, convection and forced convection, from the external surface of the sphere.

The instrument is regulated by means of the adjusting nut at the bottom of the sump, so that the operating contacts make and break at the vapor tension corresponding to a surface temperature of 75°F. This adjustment should on no account be interfered with, as this is made during the initial calibration and requires special equipment. The vapor tension in the sphere ranges, in normal winter conditions, from 12 to 27 lbs./in.^{2} absolute. If, however, the sphere were exposed to strong sunlight, or high air temperatures, the vapor tension would rise to a dangerous value; in order to prevent this occurence, the contact arrangement shown in Fig. 1 has been adopted. The operating contacts are at the top, while the summer cut-off contacts are located just below them. As the effective temperature in the room rises, the operating contacts will break, thus causing the relay to fall off and the heating apparatus to be switched off while a further rise of approximately 5°, will cause the lower contacts to break the circuit of the boiler coil. In the summer, therefore, the boiler coil will normally be switched off but should a fall in temperature occur, it will be switched on in sufficient time for the instrument to take charge of the heating installation should the fall continue.

The principle of dynamic equilibrium outlined above assures a unique combination of sensitivity and robustness. The contacts will not chatter if the instrument is jarred, while a dent in the sphere will not in any way affect the adjustment of the instrument, as the reduction in volume caused thereby will immediately be compensated for by the condensation of an appropriate quantity of vapor. The sensitivity of the instrument is such that the contacts will operate on a temperature change of ¼°F. or, in other words, the differential of the instrument is ±⅛°F. The effect of the thermal capacity of the instrument is greatly reduced by this principle of dynamic equilibrium and the response is therefore exceedingly rapid.

Calibrating Meters

(Westinghouse Elec. & Mfg. Co.)



A STROBOSCOPE is a simple mechanical device used to compare speeds. Stroboscopes have been in common use in physical laboratories for a great many years. By their means not only can speeds be compared but motions can be made to appear real slow and even to stop. A rotating airplane propeller observed through a rotating disk, having holes in it, will appear to be stationary when the disk is rotated at the same speed as the propeller, or appear to turn over slowly when the disk is rotated at a slightly slower speed.

In the picture, a girl is calibrating a house type electricity meter by the stroboscopic method. A sharp beam of light shines through openings in the rotating disk of the upper or "standard meter," which is known to be 100% correct. This interrupted light beam falls upon the disk of the meter being calibrated. It takes a girl only a few minutes to calibrate a new meter by this means because she merely moves an adjusting screw until the disk appears to stop.

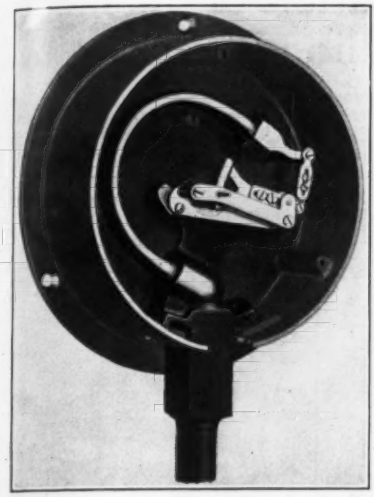
Thus, one girl, requiring no special knowledge, can do the work better and quicker than the trained laboratory operators could do it previously.

The viewing opening near the girl's left hand is arranged to magnify the marks on the edge of the tested meter disk, and is located to give the maximum convenience and repose, and thus the least fatigue to the operator.

All-Steel Pressure Gage

(Crosby Steam Gage & Valve Co.)

THE Crosby Heavy Duty All-Steel Gage, Style AIH, is designed to give exceptional accuracy and long life on severe service, such as on high pressure, high temperature oil cracking, modern high pressure steam stations, and synthetic chemical plants. It is unaf-



fected by many chemicals and fumes which attack bronze, such as sulphur and ammonia.

The tubes are completely machined from a solid bar of special alloy steel. The machining includes precision boring and turning, absolutely concentric, and the threading of the heavy end sections. The tubes are rolled to shape and radius, heat treated and tempered. All work is done under exact control.

The tube is attached to socket and tip by threads forming a mechanical joint which will not fail should high temperature fluid reach the tube. The movement, entirely of steel, is exceptional in design and material. The bearings are of stainless steel hardened and polished.

The sector and pinion are wide faced and forged to give the tough core required to withstand the blow of extreme vibration and pulsation which will break hard brittle teeth. The teeth are machined (not punched or broached), then hardened and chromium plated to resist wear.

The complete operating mechanism of the gage is carried on the socket and is, therefore, unaffected by stress applied to or distortion of the case.

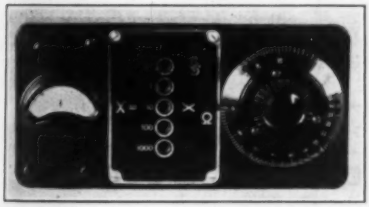
The socket is of forged steel, of exceptionally sturdy design and section. It extends well below the case and is milled to provide a wrench-fit invaluable in making up a tight joint on high pressure.

The case is dust and moisture proof; the glass bears against a gasket and is held in place by a screwed retaining ring.

"Z"-Type Measuring Bridge

(Herman H. Sticht & Co.)

IN order to make quick measurements in the workshop, laboratory and test room, or on installation work the resistance bridge used must be of small size and light weight. The instrument must allow the various operations to be executed conveniently, and should also contain the battery as an integral part. The operations must be of such simple nature that even unskilled workers can handle the instrument without any difficulties.



The new small "Z"-Type Measuring Bridge has very small overall dimensions, 9″x4¾″x2¾″, and can thus be conveniently carried in the coat pocket or brief case. Its weight is only 3 lbs. The apparatus is enclosed in a strong casing of molded material, and all working parts are of substantial design in order to withstand rough usage.

The current required for the operation o. the instrument is supplied from a battery contained within the case. The ordinary pocket lamp battery used in the instrument is easily exchangeable.

The instrument can be set up in a vertical position by simply opening the back lid which covers the battery compartment. Measurements with the bridge become thus particularly convenient when a series of protracted readings has to be taken; the engineer need no longer bend continually over the instrument in order to read both the galvanometer and the resistance scales. The "Z"-Type Bridge is manufactured in two types to suit the ranges of resistances most commonly used in practice: 0.1—10,000 ohms and 0.5—50,000 ohms respectively.

The accuracy of the instrument is about 1%. The sensitivity amounts approximately to ±0.5% for the 3 middle plug positions, and to ±2% for the other positions.

Amplification of Ten Quadrillion Times

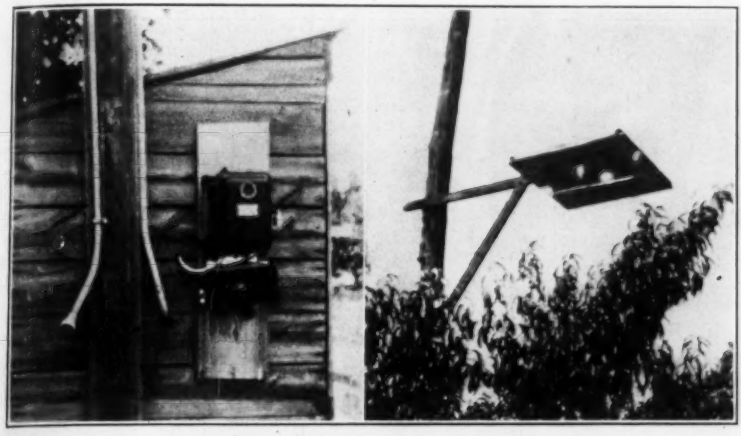
A DEVICE which amplifies an electric current ten quadrillion times was exhibited by E. S. Darlington of the vacuum tube engineering department of the General Electric Company at the radio and electric show of the Electric League of Washington, D. C., which opened September 21. The device is a low-grid-current tube, which in conjunction with a Thyratron tube is capable of utilizing 0.00000000000000001 (10^{-17}) ampere to control 0.1 ampere—or 100 milliampere—directly. The grid cap or terminal of the tube which picks up these minute charges from space is smaller than an ordinary thimble.

As a means of demonstrating the remarkable sensitivity of the low-grid-current tube, Mr. Darlington utilized the relatively small amount of current generated by rubbing an amber rod with a piece of paper to turn on and off a usual incandescent lamp, with the amber rod at varying distances of from 5 to 15 feet from the small box on which the sensitive tube was mounted. On the front of the box was a meter which showed plainly to what degree the tube was being affected by positive and negative charges obtained by rubbing the rod. Connected to the box was another one, on top of which were mounted a Thyratron tube and incandescent lamp. Current was supplied to the lamp by the Thyratron tube; and the minute charge from the amber rod was amplified by the low-grid-current tube sufficiently to operate the Thratron tube and turn the lamp on or off according to whether the charge was positive or negative. A current of 10^{-17} ampere thus directly controlled the 0.1 ampere used by the lamp—introducing an amplification factor of ten thousand million million times.

Electric Eye May Protect Orchards

ORIENTAL peach and coddling moths, foes of the peach and apple crops, may be routed with the assistance of the photoelectric eye if experiments now being carried on by the New Jersey Agricultural College prove successful. These moths cause much damage by laying their eggs on the trees in question, but they will not lay when the temperature is below 60°F. or in the daylight.

To defeat the moths it was decided to floodlight some experimental orchards and have the light turned on and off by General Electric photoelectric relays. These devices are set to operate when the light increases or decreases beyond certain predetermined limits. When darkness approaches, the photoelectric eyes note the change and cause the floodlights to be turned on; when daylight returns, the never-sleeping electric eyes turn the floodlights off again. The moths, finding a state of continual daylight, are expected to be discouraged from their egg-laying in that particular orchard.



As it is unnecessary to use the floodlights when the temperature drops below 60°, a thermostat will be used to cut out the floodlights entirely under such conditions. The moths then will be discouraged by the low temperature, as they will not lay their eggs below that temperature even though it is dark.

A foot-candle meter is used to measure the different light intensities at different parts of the orchards, to determine the minimum amount of artificial light necessary to stop the moths from laying. The trees will be examined at the end of the egg-laying season and compared with the artificial light intensity at corresponding points. The cost of the artificial lighting will then be compared with the cost of spraying trees.

The experiment is being conducted by Dr. Thomas J. Headlee, entomologist for the New Jersey Agricultural Experiment Station at New Brunswick, of Rutgers University. Dr. Headlee has also found that the color of the artificial light used has some effect on the attraction or repulsion of the insects, as well as the amount of light. It is planned to experiment with various colors of artificial light in conjunction with the other arrangements.

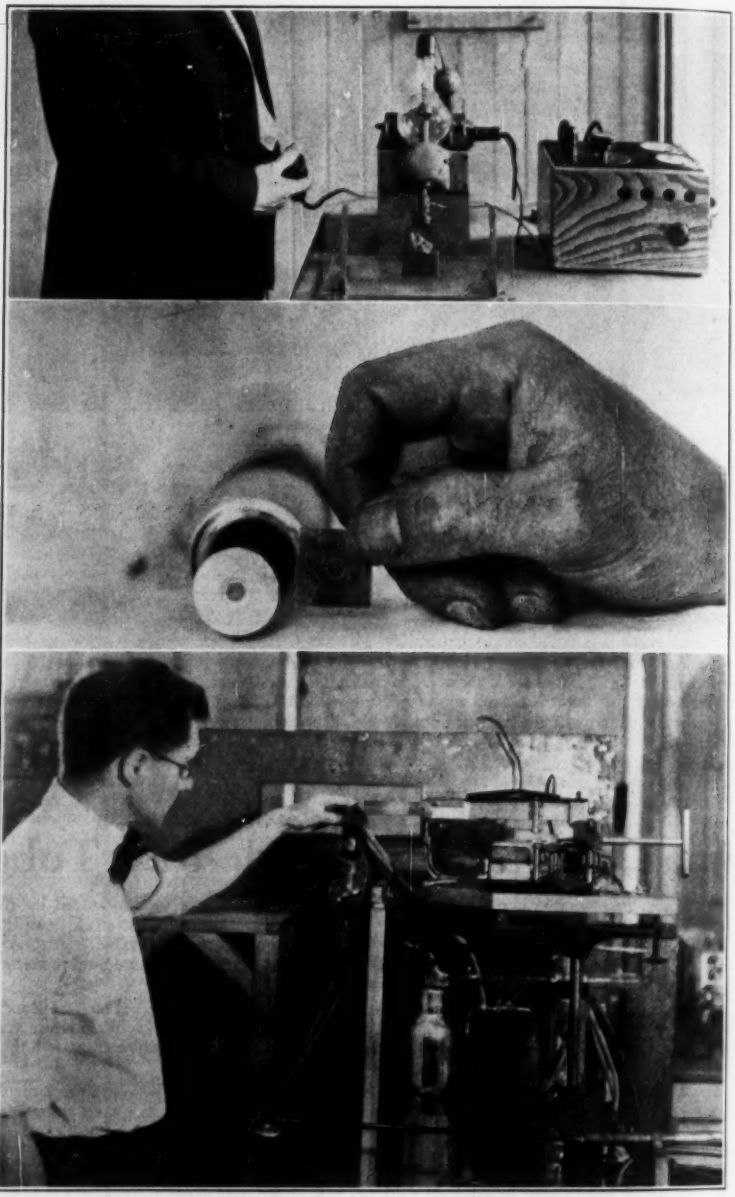
Small, Portable Cathode-Ray Tube

THE tube, in principle like the large, heavy-duty cathode-ray tubes announced by the General Electric laboratory a few years ago, is very small and compact—so small, complete with all its equipment, that it can be carried with ease and used on a small table. Although operating at 70,000 volts, it uses ordinary 110-volt house supply, a small semi-fluid immersed transformer producing the necessary high voltage.

The tube itself is only 12″ long overall, with a bulb 3¼″ in diameter. The "window," the thin piece of metal through which the cathode rays escape into the air, is of aluminum foil, the central portion of which has its thickness reduced over a number of small areas to less than a half of a thousandth of an inch.

The tube is mounted on a transformer case, measuring 8″x6″x10.″ With the tube in place for operation, the overall dimensions are only 15″x7″x14.″ The other case, containing the meters, resistances and controls, measures 10½″x8½″x8½″ overall. Both cases are provided with carrying handles.

The design of the tube is such that most effective use can be made of the cathode rays. The rays, which can be seen in subdued light as a pale bluish haze surrounding the window of the tube, are quickly absorbed and stopped by the air. With the new tube it is possible to place the object being rayed within a small fraction of an inch from the window, so that the loss in air, which would be very apparent if the window were recessed, is negligible. Similarly, the tube is designed to handle a tenth of a milliampere of current at the rated voltage of 70,000. The tube is of the same general design as the standard 300,000-volt, 1-milliampere tube, so that it follows that tubes for any intermediate voltage and current could be provided.



(Top) Mineral Specimen being Rayed with Portable 70,000 Volt Cathode Ray Equipment. (*Center*) Window of 70,000 Volt Tube. (*Bottom*) Small Cathode Ray Tube being used in Spectroscopic Analysis.

Since the tube is sealed from vacuum systems and not only the tube but also the transformer and control equipment are small and safely enclosed, the new equipment can be used in laboratory demonstrations, as well as away from the laboratory. The previous large, higher-voltage equipment demanded far more elaborate equipment and much more room, so that to move it around from place to place was decidedly inconvenient.

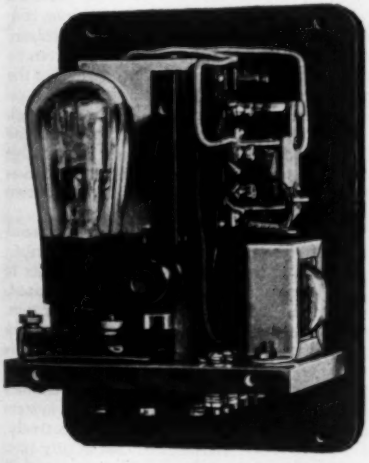
Cathode rays have not entered commerce and the professions as have their near-relatives, X-rays. The latter, incidentally, are produced when cathode-rays strike certain objects. Ordinarily the X-rays are produced within a tube by the rays from the hot cathode striking a heavy metal target, the X-rays then escaping through the tube to the air. In the cathode-ray tube, on the other hand, the electronic stream from the hot cathode strikes such a thin electrode, the metal window, that the electrons go right through the metal foil and reach the air as cathode rays. Although the cathode-ray tube has not been applied commercially, it is proving of use in scientific investigations and has been applied to examinations of natural and synthetic jewels.

One application of the small cathode-ray tube has been made in the General Electric research laboratory by Dr. G. R. Fonda in a new method of X-ray spectroscopic analysis. Such analyses are usually made with a special X-ray tube in which the target is made of the material which is to be examined or analyzed. This means that the tube must be taken apart for the insertion of samples, and it also means that many materials cannot be used since their presence within the tube would be disastrous to the high degree of vacuum which must be maintained. Since X-rays are produced when cathode rays strike an object in air, Dr. Fonda has been able to make spectroscopic analyses by placing a piece of the substance to be observed immediately beyond the window of the cathode-ray tube. By this means, he has developed a method for quantitatively determining the analysis of samples containing columbium and tantalum, two elements which present decided difficulties for analysis by purely chemical methods, involving considerable time and requiring careful attention to an exact procedure. The method developed by Dr. Fonda is such that it can be extended to X-ray spectroscopic analyses of a multitude of substances.

Light Sensitive Cell Unit

(Struthers Dunn, Inc.)

As in the case with any light sensitive cell unit, the new "DUNCO" unit will operate at practically any distance, being limited only by the distance that light can be thrown—either reflected or diffused light will operate the unit, which is adjusted at the factory for operation requiring a 10-watt lighted lamp being placed 1 ft. away. This is without the use of any reflecting lens. The unit, however, can be adjusted for more sensitive operation.



In connection with this unit, an interesting use for it has just come to light in a large jewelry store. Formerly it was the practice to leave three 100-watt lamps burning in the store all night. These, of course, did not light up the place very well—hardly sufficiently for the watchman outside to see all parts of the place. A light sensitive cell was placed in a corner of the window, without the cell exposed to view. Now only a single 100 watt lamp burns in the store, and the watchman, by means of his flashlight, operates the simple mechanism which throws on the lights in the entire store long enough to see clearly everything inside.

Restaurants are making wide use of sensitive light cell units to operate the door between the kitchen and dining room, and many stores have already placed them outside the front door, which opens when a prospective customer approaches. Hundreds of individual uses of course are being found for sensitive light cell units.

EMCO-McGaughy Integrator

(*Pittsburgh Equitable Meter Co.*)

THIS new Integrator is a development in office equipment designed to facilitate the calculation of the total extension of orifice meter charts. The salient points of the Integrator are as follows:

1. It renders the whole extension of the chart by integrating an infinite number of instantaneous square root values of pressure and differential and synchronizing each instantaneous value of pressure with its corresponding value of differential. Thus it renders a theoretically true value of the whole Extension of the chart, which it has been impossible to obtain heretofore.
2. The machine is accurate to within $^1/_{10}$ of 1% through all ranges and types of charts for which it is designed.
3. The pens on the machine superimpose ink lines on the original chart curves which makes it possible to check the work of the operator at a glance. This feature, combined with a check of counter readings by groups of charts, makes it impossible for any error of the operator to appear in the total extension used in arriving at delivery, thus eliminating the occasional error so prevalent in other methods of calculation.
4. The average operator with three weeks' experience can calculate accurately about three hundred average charts per day, rendering the whole chart calculation complete through grand total extension.

With the inspection method of chart calculation and other present known methods, certain theoretical discrepancies exist due to taking the square root of average values over finite time intervals whereas the formula calls for instantaneous square root values. Also some error is encountered due to the fact that the meter pressure and differential pens never track on exactly the same time arc of the chart; therefore there is always some time lag which is not taken into account with any present method of calculation. The inspection method is more or less a compromise and except for the time lag mentioned would become more accurate as the finite time interval used approached 0. However such procedure would involve an infinite number of calculations, hence the practical compromise of the finite time interval of 15 minutes or 1 hour.

The Integrator eliminates the time interval compromise and presents an extension which is the summation or integration of an infinite number of instantaneous values of the square root of the product of absolute pressure and differential values. Furthermore each instantaneous value of pressure is synchronized with its corresponding value of differential. Thus the result rendered is theoretically perfect.

The Integrator operates through translating into revolutions and multiplying the three given values of the chart, namely, time, square root of pressure, and square root of differential and summing up the products in terms of revolutions. An infinite number of instantaneous values are multiplied and summed up for each chart.

The machine is comparatively simple and rugged in construction and absolute precision machine standards have been closely adhered to throughout. Essentially the machine consists of 3 discs or plates which may be termed the chart plate, the time plate, and the pressure plate. The time plate and chart plate are geared together in constant ratio and are driven by a variable speed motor. The pressure plate is situated above the time plate and, geared to the pressure plate shaft, is a small steel disc roller termed the pressure roller. This roller bears on the face of the time plate and is shiftable across it from center to outside edge. Thus through shifting the position of the pressure roller it is possible to change the speed ratio between the time plate and pressure plate. A second roller termed the differential roller is shiftable across the face of the pressure plate and direct connected to this roller is a simple revolution counter. Therefore it may be said that the mechanism includes a driving plate and two superimposed frictional speed changes in series all driving a revolution counter.

The time plate and pressure plate both have rubber faces formed by vulcanizing tire tread rubber on to the metal plate. Spring pressure forces the pressure and differential rollers into positive contact with these rubber faces and as the torque required to drive the counter is very slight and the speeds attained very low, slip in the frictional drive is entirely eliminated. The maximum speed of any part of the machine other than motor and counter is 100 r.p.m. All bearings are either the annular ball bearing type or the jewel type bearing and practically all moving parts are a light aluminum alloy, thus eliminating friction and inertia insofar as is possible.

Two pen arms carrying fountain pens extend over the chart plate, the pens being in contact with the face of the plate. The rear ends of these pen arms are connected through a system of levers and cams with the pressure roller carriage and differential roller carriage respectively. This linkage is so arranged that the pen arms serve to move the carriages so that at any time the point of contact of these rollers with their respective plate surfaces will correspond in revolutions respectively to: the square root of the absolute pressure being registered at that

instant by the pressure pen; and the square root of the differential being registered at that instant by the differential pen. Two handles on the front of the machine serve to move the pressure and differential arms across the face of the chart plate in tracing the curves.

Analyzing the action of the machine, the time plate turns a certain definite number of revolutions while the chart plate turns through a known time division of the chart, say 1 hour. Therefore time plate revolutions are an index of time. At any instant during this time the pressure roller is engaged in multiplying the square root of the absolute pressure being indicated at that instant by the pressure pen by this instant of time. In other words, if the pressure pen is resting on say 85.6 lbs. static or 100 lbs. absolute the pen arm linkage will force the pressure roller to that distance from center of time plate which will cause the pressure plate to revolve exactly 10 revolutions, or the $\sqrt{100}$, while the chart plate turns through 1 hour's time. Therefore the revolutions turned by the pressure plate during any instant of time equals $T\sqrt{P}$ where T equals that fractional part of 1 hour represented by the instantaneous reading and P is the absolute pressure at that instant.

The differential is handled in the same manner, the differential pen being linked through a cam with the differential roller so that for any indicated differential the linkage forces the roller to a distance from center of pressure plate which is equal to $\sqrt{D}/r$ where r is the radius of the differential roller. For example if the differential pen rests on 25" then the position of the differential roller is such that it will turn exactly 5 times or the $\sqrt{25}$ for each complete revolution of the pressure plate.

Therefore the revolutions of the pressure plate are multiplied by the square root of instantaneous differential and as pressure plate revolutions equal $T\sqrt{P}$ then net resultant revolutions registered by the counter equal $T\sqrt{P}\sqrt{D}$ for any one instant or the summation of this expression for any definite time interval.

Therefore the result rendered by the integrator is the absolute integration or theoretically true value of the extension of the chart which it has been impossible to obtain heretofore.

Long series of tests with the Integrator show that careful inspection method calculation checks Integrator calculation on about 99% of the charts handled, the only essential differences appearing on those charts where pressure or differential or both vary widely and rapidly. The calculation of these charts, the elimination of human error, and the possibility of setting machine pens to same time lag as the meter are the only claims for increased practical accuracy advanced for the Integrator.

A ring beneath the chart plate is fitted with 96 slots, one for each quarter hour on the chart. An automatic stop bar may be set in any of these slots to stop the calculation at any predetermined point such as the end of the chart. The mechanism is so set up that both chart plate and counter are stopped instantaneously thus closely controlling the element Time.

The machine is provided with 2 control handles to move the pens across the face of the chart plate and with a foot controller to regulate the speed of the chart plate. In practice the chart is placed on the chart plate with the nearest quarter hour to start of chart directly beneath the stop control handle pointer. The stop control handle is then rotated beneath the plate until the pointer is above the nearest quarter hour to the point where chart was taken off meter. The pen control handles are grasped, the foot control depressed and as the chart plate starts to rotate the two curves are traced simultaneously. When the end of the chart is reached the machine stops automatically. The counter is non-reset therefore the Extension is the difference between the counter reading start of chart and end of chart.

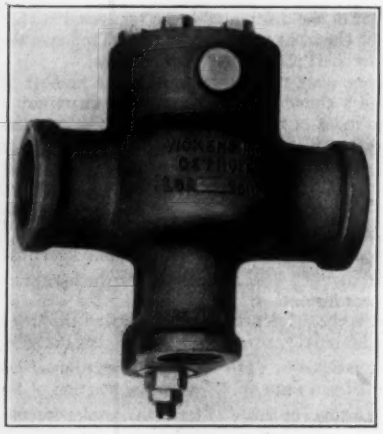
The machine pens leave light blue ink lines superimposed on the original chart curves, hence accuracy of tracing may be checked at a glance. The usual procedure in running the machine is to group the charts into groups or "runs," all charts in any one run being of the same pressure spring and differential. The counter reading start of run is noted and as each chart is run the counter reading start of chart and end of chart is noted on the chart. After all charts in the run have been completed counter reading end of run is noted. The comptometer operator then subtracts the two figures on each chart, the difference being the extension of that chart. Then the grand total of all extensions on all charts of the run should equal the difference in counter reading start of run and end of run. If this does not check there has been a mistake in copying from the counter or in subtraction, either of which is easily located and corrected. Thus an absolute check is maintained on all work of the operator.

In order to have day to day proof of the accuracy of the machine the usual procedure is to run a test chart of known value each day, recording the machine given value as compared with the known value and file these tests as permanent records. The test chart covers all ranges on the machine.

The average clerk can handle the machine with accuracy at the end of the first day and in less than 3 weeks will have attained a maximum output of about 300 average charts per day. The work is rather easier than inspection method calculation as it rapidly becomes subconscious and does not demand the mental concentration of the inspection method.

New Hydraulic Relief Valve

A HYDRAULIC relief valve, different from those now on the market, has been announced by Vickers Inc. Instead of the customary spring-loaded construction, it is operated by a piston that is in hydraulic balance regardless of the initial oil pressure and the pressure for



which the valve is set. Consequently, it is more sensitive and has greater accuracy throughout the pressure range.

Another advantage of this hydraulic relief valve (balanced) is that it is installed directly in the line and in any position—this eliminates the customary tee and results in a neater and more compact installation. Longer life is assured by alloy steel working parts that are hardened and ground to close limits.

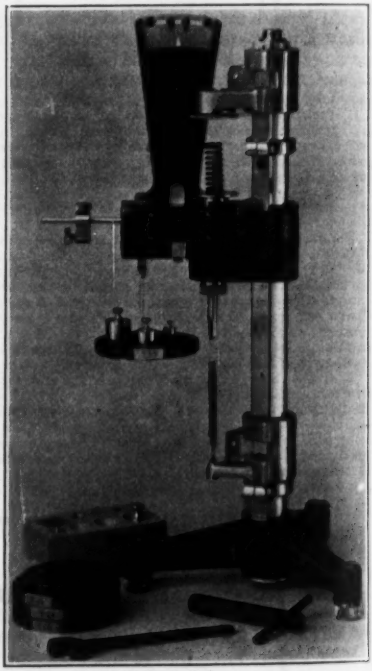
A hydrocone shaped valve prevents wire-drawing and eliminates oil foaming which aerates the oil. The Vickers hydraulic relief valve (balanced) is non-surging and its operation is quiet since the balanced piston makes chatter impossible. The control is very simple; turning the adjusting screw will vary the pressure from one extreme to the other.

The hydraulic relief valve (balanced) is made in 2 sizes—for $\frac{3}{4}$" and $1\frac{1}{4}$" pipe connections. Their capacities are 0 to 15 gal. per min. respectively. The pressure range for both is from 0 to 2000 lbs./in.^{2}

New Spring Testing Machine

(*Coats Machine Tool Co.*)

THE Elasticometer, type RS 2 (5 lbs. load limit) can be used for making accurate compression and extension tests of light springs such as typewriter or adding machine springs. Scale ratio 1:1. It works on knife-edges in the same manner as the larger machines and has been designed to satisfy the demand for a machine particularly suitable for the quick inspection of light springs. Since the machine has a maximum load capacity of only 5 lbs., the scale consists of a single lever in the ratio of 1:1. From the outer end of this beam or lever, the weight-carrier is suspended whereas the inner end supports a bar, guided in steel balls, which carries a compression plate or platform above and a tension hook below. A pointer, directly fastened to the beam, completes the weigher scale which latter is enclosed in a housing, arranged to slide on the pillar of the machine and to which it may be clamped. Tension and compression tests are made by means of slides. Adjustable stops limit the motion of these slides for quantity inspection. A water level is provided on top of the column indicating horizontal alignment of the tripod base.



Only the main knife-edge is mounted in the Elasticometer when the machine leaves the factory. The remaining parts of the weigher mechanism are wrapped separately and packed in a box. They are readily assembled. This arrangement not only prevents damage in transit, but also makes for easy accessibility, permitting periodic inspection and cleaning of the weighing mechanism.

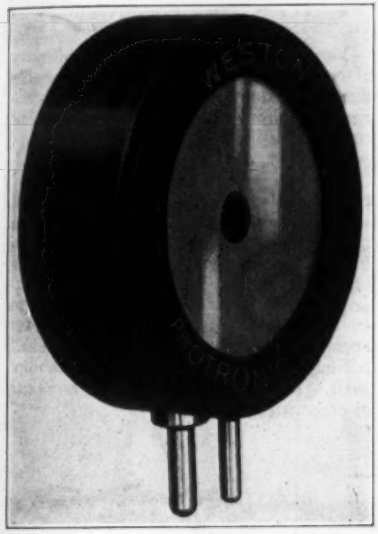
The load is determined by placing loose weights on the weight-carrier. Variations in length are read in 1/16", a vernier on the slide permitting readings as close as 1/128" on the vertical length scale engraved directly upon the pillar in such a way that the actual

length of the spring in either its free, compressed or elongated state is indicated. Movable tolerance markers for length slide in a groove of the pillar whereas tolerance markers for weight are mounted close to the top of the fan-shape housing directly above the scale over which the indicating hand slides.

New Photoelectric Cell

(*Weston Electrical Instrument Corp.*)

FOR many years photoelectric cells have been serving an extremely useful mission in experimental and industrial work in controlling the operation of apparatus and equipment, in controlling various processes and in many counting operations. A number of different type cells have been available for experimental, commercial and scientific applications. Each type, however, had its own inherent limitations in operating performance or had to be used in conjunction with expensive auxiliary equipment.



The discovery of an ideal type of photoelectric cell has been the subject of continual scientific research. To be of the most practical value the cell sought after should combine all the good qualities of existing cells with none of their shortcomings or limitations. Such a cell would be truly ideal but its successful attainment has been a baffling scientific problem.

The Weston Photronic Cell employs a highly light sensitive disc which transforms light energy directly into electrical energy without the use of any auxiliary voltage whatsoever. Its response to light variations is instantaneous and sufficient current is developed to directly operate Weston relays without the use of auxiliary apparatus or any battery. It delivers about one microampere per foot-candle of light intensity. When exposed to direct sunlight the output is approximately 5 milliamperes. The cell resistance varies from about 1500 ohms for 10 foot-candles light intensity to about 300 ohms for 240 foot-candles intensity.

As far as is known, the life of the cell is practically unlimited and a continuous current flow does not harm it in any way. Since it does not contain any liquid or require vacuum or gas, there is nothing to get out of order as it is not subject to physical or chemical change and it has a constant output. It can be exposed to direct sunlight without deterioration, has no dark current since its energy is derived directly and only from light; no drifting, hence no circuit adjustments are necessary; no fatigue and it is non-microphonic.

The Photronic cell is enclosed in a handsome molded black Bakelite case fitted at the bottom with two connection prongs which fit into the standard UX radio tube socket. It is rugged in construction and is so simple in design that there is nothing to get out of order. The case is 2¼ inches in diameter and 1 inch in thickness.

Special Duty Automatic Timers

(*Walser Automatic Timer Co.*)

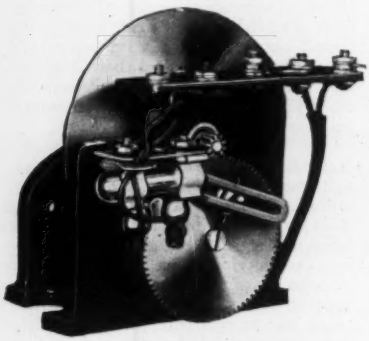
ELECTRICAL products which depend on manual control for interval operation are outdated. Today, the efficiency and convenience of automatic control is recognized by the user and the maker alike. Many products are being improved with automatic timing resulting in greater satisfaction and insuring safety, uniformity and accuracy. They include

toasters, percolators, radios, waffle irons, fans, heating pads, cookers, hairwaving and washing machines, dough mixers, motors, water heaters, therapeutic appliances and much other equipment.

The model 64A timer, designed for extended operating periods and regular time interval requirements, allows accurate fractional minute settings of from 5 seconds to 4 minutes. Once the pointer has been set for a timing interval, no further adjustments are necessary, unless the time is to be changed. The timer may be operated without interruption by simply pulling the switch lever forward until circuit is closed and mechanism started. When set time has elapsed, circuit opens and lever returns to starting position.

In black enameled steel housing; six ampere, 110 volt, A.C. and D.C. switch. Diameter, 4 in., depth, 1½ in.

Model 64A

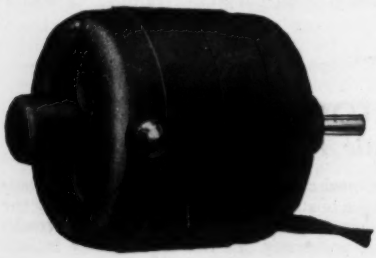


Model 90

The Model 90 timer provides a continuity of opened and closed circuits, in variable duration and interval. By regulating the speed of a revolving disc, the intervals of circuit make-and-break and the duration of current flow, can be increased or reduced. Obtainable, with or without housing, for opening and closing circuit within three to six second intervals. Special gearing required for greater timing intervals. Mercury-to-mercury tube switch, of indefinitely long life, is supplied for 110 volt, A.C. up to 20 amperes capacity in single circuit; and up to 40 amperes in two circuit. Disc motor operated and equipped with two special ball bearings and end thrust bearings to stabilize shaft. Requires little current and no oiling or other attention.

New Series Universal Motor for Small Appliances

A 20-BAR mica-insulated commutator is a new feature of the Type "V" series universal motor built by the Bodine Electric Company. Increasing the number of commutator segments from 10 to 20, insulating the segments with high-grade mica, and grinding the commutator on the bearings, eliminate in this motor the commutation troubles often experienced with small motors of this type. These motors are rated at 1/100 h.p. at 4000 r.p.m. and are designed for 110-volt service, direct or alternating current.



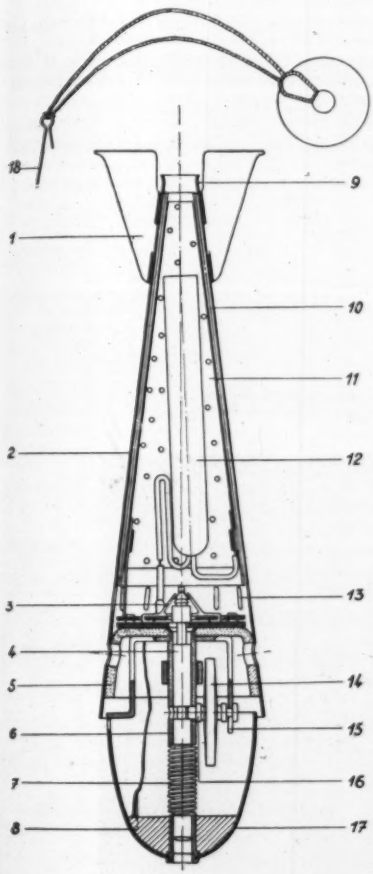
Special attention has also been given to lubrication. The shaft is oiled through a felt ring. At the end of the shaft is a felt-packed reservoir in which lubricating oil is retained over a long period of time and slowly fed to the oil wick through an intermediate felt washer. Any oil which might travel toward the commutator is thrown off centrifugally by a bakelite protecting ring.

Electrosounder

(*Echometer, G. m. b. H.*)

THE Electrosounder serves for the measurement of water depths. It is different from the usual form of sounding devices, in that it is not lowered down by means of a line, but simply thrown into the water.

Contrary to the law which governs the fall of a body in air, which gradually accelerates, the Electrosounder sinks in the water after a short interval with a constant speed of 2 meters per second due to the resistance of the water through which the body is passing. When the body reaches the bottom of the sea, a small electric circuit is closed which causes the detonation of a small capsule. At great depths the detonation can be easily listened for by means of the known submarine sound receivers for navigation in fog, which most ships are equipped with; while on board of many ships (especially small ones) it can be perceived with the ear.



The depth of water under the ship can be determined in a very easy manner by multiplying by two the time taken for the apparatus to fall to the bottom of the sea, which gives the depth in meters. For the measurements, there is required besides the submarine sound receivers in the ship, an ordinary stop watch which is started when the apparatus is thrown overboard and stopped when the explosion of the capsule is heard.

Fig. 1 shows the Electrosounder in section through its longitudinal axis.

The principal framework of the Electrosounder is indicated at (5) which constitutes the framework of the mechanism and serves as the weight when the apparatus sinks.

The cone-shaped cover (2) fits above the frame (5) and carries the two tail steering devices (1). (17) is a parabola shaped cover in which the contact pin (4) is fixed. This contact pin can be pushed forward in the tube (6) and carries a little contact head which can close the circuit between the contact springs (3).

On the apparatus striking the bottom of the sea, the blow causes the contact pin to rise until the contact springs (3) engage in grooves turned in the contact pin and close a circuit for the electrical capsule. The capsule contains about 0.8 g. Nitropentaerythrit.

In the normal position a spring (7) keeps the contact pin pressed well clear of the springs (3). The current to detonate the capsule (12) is supplied by a galvanic element, of which one electrode consists of the above-mentioned cone-shaped cover made of sheet zinc, into which the second electrode—a similar shaped copper cone (11)—is fitted. The latter has holes formed in it to allow of the passage of the water. Between the two electrodes there is a porous stratum (10) in which an electrolytic salt is in suspension. Two different sulphates are used for this which ensure constancy of the galvanic cell. As long as these salts are not dissolved, the galvanic element does not provide any current. Slots (13) are cut in the outer cover which facilitate the entrance of water to the interior portion of the mechanism, and a tthe top end of the conical cover, a hole is bored at (9) to allow of the escape of the air.

The apparatus is protected against premature firing in three manners:

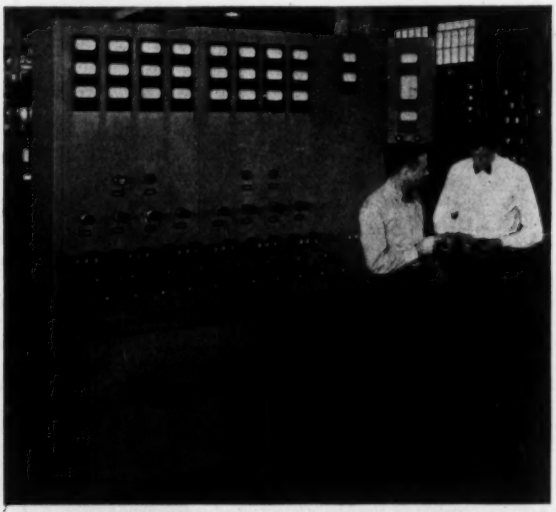
First, by means of a thin metal watertight capsule (14) which is secured at one end into a clip (15), whereas the other end carries a locking pin (16) which engages in a groove formed in the contact rod (4). Under atmospheric pressure the capsule preserves the shape indicated in the figure. When the apparatus is thrown into the water, the pressure as it sinks causes the capsule to collapse and the locking pin (16) is withdrawn from the groove, so permitting the rod (4) to move freely upwards—the pressure resulting from a depth of about 4 meters causes the capsule to collapse and free the rod.

The second safety device is effected by the galvanic battery element which can only furnish current to the explosive capsule when the porous stratum (10) is thoroughly saturated. This requires complete immersion for a time of not less than 2 seconds. Rain and spray are not sufficient to get the galvanic element ready for use.

The third safety device consists of a spring clip (18) which normally is placed through the hole (9) in the upper portion of the casing. The clip (18) keeps the two electrodes, zinc and copper, short circuited, so that, until the clip is pushed off by the cord attached to it, it is impossible for sufficient current to be generated to explode the capsule (12) even if the electrolyte is well soaked and the contacts are connected.

The connections are very simple. One wire of the firing circuit is secured to the springs (3) and the second is attached to the copper cone (11). When the contacts (3) are connected, the current flows from the copper cone (11) (positive) through the fusible wire in the capsule (12) to the contacts (3) and through the flexible connection (8) to the zinc cone (negative).

Art in Engineering



One of the first practical demonstrations of the modern "art in engineering" idea as applied to apparatus design, is found in the control desk just shipped by the Westinghouse Electric and Manufacturing Company to the Harding Street Power Station of the Indianapolis Power and Light Company, Indianapolis, a subsidiary of Management and Engineering, Inc., Chicago. A. J. A. Peterson, left and G. H. Welch, designing engineers of Westinghouse, are holding the first and the final models of the minatrol switch used on the desk. More than 20 different designs were used before a satisfying combination of artistic beauty and engineering efficiency was evolved.

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POTENTIOMETER PYROMETERS. A 16 page booklet explaining and illustrating the principal features of a new potentiometer pyrometer. The Brown Instrument Co. 4482 Wayne Ave., Philadelphia, Pa.

FLOW INSTRUMENTS. Catalogue No. 1020 describes flow recorder-controllers for liquids, flow meters and orifice meters for gases, etc. Also numerous photographs and diagrams of applications. C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, N. Y.

TELEMETERS. Bulletin No. 27 is descriptive of a group of pressure, load, strain, etc. testing and measuring devices, based on the use of carbon-pile resistors for the measurement of small motions. Baldwin-Southwark Corp., Paschall Station, Philadelphia, Pa.

METEOROLOGICAL INSTRUMENTS. A 140-page stiff cloth bound book entitled, "Standard Meteorological Instruments" describes the patterns and types which are specially recommended by the Meteorological Authorities of the British Isles. Negretti & Zambra, 38 Holborn Viaduct, London, E. C. 1, England.

RESISTANCE BRIDGE. A circular describing a small "Z" type measuring bridge developed for general use in the workshop, laboratory or test room, for the travelling engineer and general installation work. Herman H. Sticht & Co., 15 Park Row, New York, N. Y.

pH INDICATOR. Circ. 7654g-G illustrates a Quinhydrone pH Indicator of potentiometer accuracy, yet several times as fast and convenient as electrometric pH indicators which use hydrogen electrodes. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

THERMOSTATS. A leaflet entitled, "Plant Insurance and Absolute Protection for Greenhouse Growers." Standard Thermometer, Inc., 65 Shirley St., Boston 19, Mass.

THE SPERRY HORIZON, is the title of Publication No. 15-450. This booklet explains why the Sperry Horizon was developed, how it works, and how it is used. The purpose of the Horizon is to take the place of the natural horizon when it is obscured by darkness or fog or any other condition which prevents exterior visibility. Sperry Gyroscope Co., Inc., Manhattan Bridge Plaza, Brooklyn, N. Y.

THE GRAPHIC. No. 731 of this publication contains an article "Graphic Instruments Effect Saving for Masonite" by W. A. Cotton, Jr. The Esterline-Angus Co., Indianapolis, Ind.

SMOKOMETER. A loose leaf describing the Smokometer for indicating smoke density in boiler breechings. The Sales Corporation, Richmond, Va.

MICROSCOPE RECORD. The September 1931 issue features the following articles: "The Microscope in the Service of Textiles" by H. Ellis; "Early Photomicrographers" by C. H. Oakden and "Are You Getting the Most out of Your Microscope?" by J. Johnston. W. Watson & Sons, Ltd., 313, High Holborn, London, W.C.1, England.

MULTI-SPEED DRIVE and CAPACITORS. Leaflet, L.20520 gives information on the application, operation and construction of the Multi-Speed Drive. Leaflet 20044-F covers group-type capacitor equipments for power factor correction on 60-cycle circuits. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

LATHES. 128-page Catalogue No. 92 featuring countershaft drive lathes, motor drive lathes, tool room lathes, bench lathes, junior lathes, etc. South Bend Lathe Works, 425 East Madison St., South Bend, Ind.

POTENTIOMETERS. A reprint from A.I.E.E. Transactions, Vol. 50 No. 4, 1931 entitled "Design of Potentiometers" by I. Melville Stein. 3294G describes a "Pinch Type" d.p.d.t. Swith. The click holds switch open until user pinches handle. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

TRUCK RECORDER. A letterhead circular describing a recorder that gives complete information on the performance of trucks. The Service Recorder Co., Hanna Bldg., Cleveland, Ohio.

RESISTANCE BOXES. A leaflet describing and illustrating resistance boxes for precision measurements at audio and higher frequencies. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

TYCOS-ROCHESTER. The October, 1931 issue of this publication contains the following articles: "Getting New Light on the Earth's Interior;" "Weather Service and Airports;" "Forty Centuries of Weather Records," etc. Taylor Instrument Companies, Rochester, N. Y.

SINGLE PHASE MOTORS. Leaflet 20516 describes a new single phase motor which has extensive applications on pumps, compressors, ventillating fans, blowers, farm machinery, due to its excellent torque characteristics. Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

BAKELITE INFORMATION. "Time Has Wrought Great Changes Since the Days of the Little Red School House" is the title of the October, 1931, Number 21 of this publication. Bakelite Corp., 247 Park Avenue, N. Y.

GAGE PROTECTOR. A folder describing a simple three-part, bronze bodied, rubber bulbed pressure transmitting instrument, used to transmit line pressures to gage recordings by means of a secondary, or bulb pressure; said recordings being the result of the compression of said secondary bulb liquid by a given line liquid. Champion & Barber, 576 Subway Terminal Bldg., Los Angeles, Calif.

WATER WORKS JOURNAL. The September, 1931 issue of this publication features the following articles: The History and Development of the Water Supply of Portland, Oregon; Drought Problems; Tulsa, the Leading Airport, etc. Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

SHIP INSTRUMENTS. A 48-page booklet identified as Catalogue No. 2 contains various instruments used on ships. Cummings Machine Works, 255 Atlantic Ave., Boston, Mass.

"PERFORMANCE DATA," a new 32-page pamphlet shows numerous illustrations of jigs, fixtures, dies, molds and special parts that have been drilled and bored on various jig boring machines. The R. Y. Ferner Co., Investment Bldg., Washington, D. C.

FLOW GAGES. A circular describing and illustrating vertical scale volumetric flow gages. Sarco Company, Ltd., 133 Acre, London, W.C.2, England.

METALLOGRAPHIC POLISHING MACHINES. 20-page Catalogue No. 1196 entitled Automatic Metallographic Polishing Machine, contains literature on grinding and polishing equipment for metal specimens. E. Leitz Inc., 60 East 10th St., New York.

GRAPHIC INSTRUMENTS. Circular No. 931 describes flush type graphic instruments. Esterline-Angus Co., Indianapolis, Ind.

AUTOMOTIVE ACCELERATION & BRAKE METERS. A circular describing a performance meter designed for accurately measuring the performance of any motor vehicle. Burton-Rogers Co., 857 Boylston St., Boston, Mass.

GAS ANALYSER. A leaflet describing the portable "Gasalyser" which was developed to replace many of the existing tedious gas analysis methods. It has been designed for checking gas percentages electrically and for measuring temperature. Charles Engelhard, Inc., Chestnut St. and N.J.R.R. Ave., Newark, N. J.

GAS SERVICE JOURNAL. The September 1931 issue of this publication features some of the following articles: Municipal Ownership; Science in Industry; The Ignition Velocity of Gas Mixtures, and the October, 1931 issues contains the following: Distribution Problems in Changing from Manufactured to Natural Gas; The Conditioning of Natural Gas; and The Odorization of Natural Gas. Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

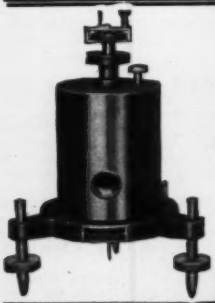
INDUSTRIAL INSTRUMENTS. 100-page Catalogue No. 1000 presents the complete line of TAG controllers, recorders, dials, thermometers, hydrometers, oil testing instruments and moisture meters. Many interesting photographs are also contained in this catalogue. C. J. Tagliabue Mfg. Co., Park and Nostrand Ave., Brooklyn, N. Y.

EXPERIMENTER. Vol. VI. October, 1931 features an article on Thermocouples for electrocalorimetric measurements. The General Radio Co., 30 State St., Cambridge, A., Mass.

CAPACITORS. Leaflet 20044-F covers group-type capacitor equipments for power factor correction on 60 cycle circuits. Westinghouse Electric & Mfg. Co. East Pittsburgh, Pa.

RADIATION TUBE. A booklet, entitled, "There is Something New Under the Sun," introducing a rapid recorder radiation tube. The Pyrometer Instrument Co., 103 Lafayette St., New York, N. Y.

ELECTROCARDIOGRAF. A number of small circulars giving the outstanding points of the portable standard electrocardiograf. Sanborn Company, 26 Lansdown St., Cambridge, Mass.



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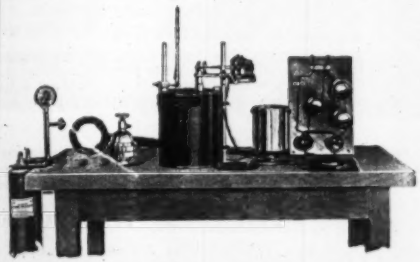

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Abstracts on instruments and devices for measurement, inspection and control

The Technology Department, Carnegie Library, Pittsburgh, Pa., will furnish photostats of material abstracted here. Negative prints are 35 cents per page, plus 10 cents for mailing (first class). All orders should be paid in advance. The library is not responsible for loss in mail.

On the Measurement of the Sound Transmission of a Partition. A. E. Knowler. London, Edinburgh, & Dublin Philosophical Magazine, & Journal of Science, Aug. 1930, pages 342-344.

Describes method and calculations for determining the transmission of sound through partitions. A beam of sound is directed at the partition on the other side of which is a moving coil loud-speaker.—R. H. P.

Vibration Tests on Steam Turbine Nozzles to Determine the Quality of the Riveted Joints between Nozzles and Peripheral Holding Bands (Schwingungsversuche an Dampfturbinenschaufeln zur zahlenmässigen Bestimmung des Gutegrades der Nietverbindung zwischen Schaufeln und Deckbändern). G. Kirchberg. Forschung und Technik, 1930, pages 478-489.

A special test arrangement is described with which the frequencies of vibration of steam turbine nozzles and bundles of nozzles can be determined and compared with calculated values. From the tests, it is concluded that the quality of the joint between nozzles and bandage is of a constant value and does not depend on the dimensions of the nozzles. The theory of the calculation is given and numerous oscillograms illustrate the process.—Ha.

Vibration Recorders. Electrical Review, Nov. 28, 1930, page 932.

Brief description of the Trub, Tauber miniature portable universal 3-component vibration meter. Intended primarily to give a chart record of the vibration and shocks occurring on locomotives and rolling-stock. Comprises three independent miniature seismographs, each of which records one of the three components.—M. S.

The Damping Factor in Vibrations. A. L. Kimball. Product Engineering, November 1930, pages 499-501.

Special reference to prevention of vibration and noise. Mathematical treatment following a most lucid discussion of the logarithmic decrement, the energy dissipation per cycle, etc. Values of damping constant for 17 materials are given.—M. F. B.

Torsional-Vibration Dampers. (Annual Meeting Paper). J. G. Baker and J. P. Den Hartog. S. A. E. Journal, February 1931, pages 184-190.

In internal-combustion engines operating over a wide speed-range, critical speeds of torsional vibration cannot practically be avoided. The ensuing vibrations, if not checked, set up high alternating stresses in the shaft which have in numerous cases led to fatigue failures, many of these occurring in the crankshaft. Several devices that successfully limit these stresses to safe values during any critical speed have been developed. The fundamentals of torsional vibration and these stress-limiting devices are discussed. According to authors, stresses set up during a critical speed can be calculated in advance. Tests made on a model in the laboratory are described and the results thus obtained prove the methods of calculation to be reliable. 14 figs.—M. F. B.

Method for Measuring the Amplitude and Frequency of Vibration of Bodies which may be Heated to Incandescence. Wilbur E. Meserve. Review of Scientific Instruments, January, 1931, pages 47-48.

Life of lamps which are subjected to mechanical vibration will be very considerably shortened if frequency of vibration of body to which lamp is attached is equal to natural period of vibration of any portion of the filament. In the method described a photoelectric cell with vacuum tube amplifier is used in connection with a stabilized cathode ray oscillograph.—M. F. B.

LIGHT, COLOR

A Comparator for Spectroscopic Work. Erik Baecklin. Review of Scientific Instruments, Nov. 1930, pages 662-666.

Disadvantages of usual types of comparators for measurement of spectral plates are stated. New comparator, intended especially for measurement of small spectral plates, designed in 1928 at Upsala University and constructed there. Chief improvement is that both eyes are employed under circumstances like those of ordinary vision; a magnified real image of the object plate is formed on a white screen with the aid of a photographic objective, but measurements are not made on image as with comparators employed in industrial work, but carried out in the object plane as with microscope comparators. Magnification can be changed. Common automobile lamp can be used. Further developments will make instrument suitable for completely objective measurements. Instrument has been used with success as a microphotometer.—M. F. B.

New Design Vacuum Grating Spectrograph. F. Simeon & C. F. Smith. Review of Scientific Instruments, Sept. 1930, pages 512-516; Instrument World, Dec. 1930, page 185-186.

Full text of the description of the new Hilger vacuum grating spectrograph originally designed by Sawyer in 1927 is described.—M.F.B.

A Quartz Monochromator and its Spectral Transmission. W. E. Forsythe & B. T. Barnes. Review of Scientific Instruments, Oct. 1930, pages 569-575.

Ample description, with photograph and diagrams, of monochromator with large light gathering power and dispersion constructed at the Incandescent Lamp Department, Nela Park, Cleveland, for use in studying the intensity of the radiation in the ultra-violet spectrum of various sources. Two Cornu prisms are so mounted and rotated that each remains in the position of minimum deviation as the instrument is rotated to bring different wave lengths into the observing slit. The screw controlling the motion of the movable arm is provided with a drum the scale on which can be read to 1 A. U. between 3600 and 2600 A. U. Lenses are quartz fluorite anachromats and their position accurately determinable by focusing screws. Slits are bilateral and adjustable. External stray light exclusion and internal stray light reduction are thorough. Mechanical construction has been done so well that setting on one spectral line can be repeated after setting on others. The set-up for determining transmission, by measuring intensity of monochromatic radiation before and after passing through the instrument, is described. Results with different slit widths, etc., showed that absorption in prisms and lenses, originally considered negligible, was appreciable in shorter wave lengths.—M. F. B.

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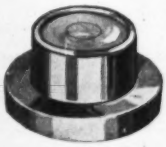

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Scientific Matching of Colors. Guy Bartlett. Metal Cleaning & Finishing, April 1930, pages 353-354.

A new recording color analyzer has been invented by Arthur G. Hardy. Reflected light from the specimen and magnesium carbonate standard is changed by a series of operations into a pulsating current which operates a small motor. The motor, in turn, actuates a shutter mechanism to which a pen is attached to record the reflecting power of the specimen on a rotating drum. A complete color analysis may be had by means of the instrument.—M. S.

The Lustre of Textile Fibres and a Method of Measurement. M. O. Pelton. Transactions Optical Society, 1929-30, No. 4. pages 184-200.

The luster of textile fibres is due to a geometrical property of transparent cylindrical filaments with polished surfaces. Some of the factors, notably double refraction and diffraction, which might affect lustre are discussed, and a method is suggested for measuring lustre based on the high lights visible on a curved lustrous surface.

The Logarithmic Wedge Sector and Its Use in Quantitative Spectrum Analysis. F. Twyman and F. Simeon. Transactions Optical Society, 1929-30, No. 4, pages 169-183.

A logarithmic wedge sector is described and its method of use and a number of factors which need attention in this connection are considered. A discussion of the validity of the law of reciprocity in the case of intermittent exposures is given. The application of the apparatus to quantitative spectrum analysis is indicated.

A Re-Determination of the Mixture Curves of the Spectrum. W. D. Wright. Transactions Optical Society, 1929-30, No. 4, pages 201-218.

The paper describes a method that has been developed for calculating the sensation curves and mixture curves from an average set of trichromatic coefficients and the standard luminosity curve, without recourse to any further experimental data. A complete table of color mixture data is given. The practical value of different methods of colorimetry and the most desirable primaries for use as reference standards are briefly discussed.

Precision Actinometry with Uranyl Oxalate. Wesley Glick Leighton and George Shannon Forbes. Journal American Chemical Society, Aug. 1930, pages 3139-3152.

Detailed suggestions for actinometry in monochromatic and in polychromatic light are offered. —M. E. H.

A Source of Error in Polariscope Measurements. H. K. Miller and James C. Andrews. Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, page 283.

To insure absence of the turbidity effect in polariscope measurements, it is suggested that duplicate trials be made with tubes of different length. Data are given to illustrate the effect of turbidity on measurements with 1 and 4 dcm. tubes—M. F. H.

Rapid Method of Qualitative Color Comparison for Opaque Solids. John J. Shank and Joseph S. Martin (Wayne Laboratories, Waynesboro, Pa.) Industrial & Engineering Chemistry, Analytical Edition, July 15, 1931, pages 343-344.

This article describes a simple comparator for opaque solids. It is designed for use in industrial plants for the rapid checking of products in which small differences of color are not easily distinguishable.—M. E. H.

The Pfund Glossmeter Applied to Paints and Lacquers. George S. Haslam and Lester D. Grady, Jr., (The New Jersey Zinc Co., Palmerton, Pa.) Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 346-348.

An apparatus is described that measures objective gloss, the property that depends on the degree of surface perfection. Color and brightness differences are eliminated entirely from the measurement. The apparatus is adaptable to paint and lacquer problems.—M. E. H.

The Measurement of Turbidity. C. D. Ingersoll and R. E. Davis (The Spreckels Sugar Products Laboratory, Yonkers, N. Y.) Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 248-249.

Presented before the Division of Sugar Chemistry at the Atlanta Meeting of the American Chemical Society, April 1930. The apparatus is shown by diagram. The method consists in this: A beam of monochromatic light is passed through the solution under examination and, theoretically, at zero depth from the surface of the liquid. The operator then observes the beam of light through a vertical tube having an optically flat bottom, and adjusts the depth of a dichromate solution, free from Tyndall cone, until the Tyndall cone in the solution under examination is eliminated from view. The depth of dichromate solution which is adjustable through leveling bulb, is considered a measure of the turbidity.—M. E. H.

An Optical Wedge Flashometer. N. H. Brachman and C. W. Kendall. The Review of Scientific Instruments, February 1931, pages 111-117.

This paper reports in detail the work done at the laboratories of the Material Division, U. S. Army Air Corps, in studying flashlight powder mixtures for use in night aerial photography with this specially developed apparatus for measuring the intensity-time characteristics of the flashes. Previous apparatus having failed to give a true measure of the variation of the light intensity, the new design employs a neutral optical wedge, in accordance with the principle of the wedge spectrograph. Records obtained are illustrated, and the rectified records replotted in rectangular coördinates show the absolute photographic intensity of the light during the flash. It is believed that the same principles may be applied to other problems involving the determination of light intensities varying over a considerable range.—M. F. B.

The Rotating Sectored Disc. B. W. Bartlett. The Review of Scientific Instruments, February 1931, pages 96-110.

A mathematical treatment opens this paper: The problem is analyzed from a new point of view, in which persistence of vision and other heretofore neglected factors are dealt with. The theoretical analysis was checked experimentally, and the various discs and the procedure are described. Results are elaborately reported. They are in accord with the analysis. Applications to fields other than the measurement of regulation of rotational velocities suggest themselves: The apparatus has been used by the author to demonstrate physically the properties of Fourier's series. Similarly a set up might be used in harmonic analysis of periodically varying sources of illumination, e. g., the neon lamp and other glow discharges.—M. F. B.

A Description of the Three Prism Spectrograph for the Royal Observatory, Edinburgh. J. H. Dowell, F. R. P. S. Transactions Optical Society, 1929-30, No. 4, pages 226-228.

The design of the described spectrograph follows closely that of the Dominion Observatory, Vancouver, with several improvements. A source of weakness in spectrograph body had been large opening for access to prisms and this was overcome by strong webs and flanges. Contrary to usual custom, camera mounts are attached directly to adjacent prism mount. Entire spectrograph body is enclosed in an outer temperature case lined with felt, over which heating elements are uniformly distributed.—M. F. B.

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Investigations into the Dependence of Measuring Accuracy on Artificial Illumination. (Untersuchungen über die Abhängigkeit der Messenauigkeit von der Künstlichen Beleuchtung). B. Reiter. Elekt. Zsch. Vol. 52, No. 7, Feb. 12, 1931, page 213.

Doctor thesis at the Technische Hochschule Dresden 1929. Experiments were made to determine the influence on the sensitivity of the eye due to changes of momentary and general adaption; the tests were made on the accuracy with which a vernier could be adjusted with changing strength of illumination. For various materials with different kinds of surface, polished and rough, light lines on dark background or vice versa, the most suitable strength of illuminations were determined. The individual results must be seen in the paper.—Ha.

Direct-Reading Photometer for the Industrial Measurement of Electric Lamps (Photomètre à lecture directe pour mesures industrielles des lampes électriques courantes). G. T. Winch. L'Industrie Electrique, Oct. 10, 1930, pages 437-443.

Condensed translation from Journal of the Institution of Electrical Engineers, May 1930, pages 533-543. Describes development and construction of a photo-electric photometer suitable for measuring incandescent electric lamps of the vacuum and gas-filled 10-watt to 100-watt types. Measurements are made on a direct-reading lumen scale. The apparatus can measure lamps at commercial speeds under continuous service conditions. Construction is simple and uses mainly standard component parts.—M. S.

Photo-Electric Cells. T. Thorne Baker. Electrical Review, Oct. 31, 1930, pages 722-723, Nov. 7, 1930, pages 768-769.

Account of some of the types of photo-electric cells and of some of their industrial applications. Some of these are their adaptation to various types of photometers and measurement of the amount of ozone in the upper atmosphere, opacity of paper during its manufacture, light intensity in the various systems of photo-telegraphy, television, and sound recording, and amount of light used in therapeutic treatment.—M. S.

The Filling of a Spectrograph with Light Considered as a Geometrical Radiation Problem. By J. Rud Nielsen. Journal of the Optical Society of America, December, 1930, pages 701-718.

An extended theoretical and mathematical treatment. To determine the maximum amount of light that may be utilized in a given prism spectrograph in the case of a spatially extended light source is of considerable importance whenever a radiation of low intensity is the object of spectrographic study. The paper discusses this problem from the standpoint of geometrical optics, without taking diffraction into account (purposely). The paper first takes up the case of no condensing lens in front of the spectrograph slit. Then this assumption is dropped and the most efficient use of a condensing lens is investigated. Finally, a brief discussion is given, in the light of the formulas derived and developed, of the speed of a spectrograph and the design of a collimator.—M. F. B.

A Suggested Method for Applying the Slitless Spectrograph to the Measurement of the Doppler Shift. By Noel Deisch. Journal of the Optical Society of America, December, 1930, pages 685-692.

A stellar spectrograph of the objective prism type has been adapted to be worked in either of two operative settings, the change from one to the other setting being made by reversing the prism and shifting the telescope on its declination axis through an angle of twice the deviation of a mean wave length of the projected spectrum. Making two exposures, one in either position, results in obtaining contiguous spectra, on which the distance separating the shifted lines differs from that which separates the basis of the method discussed in the paper. A composite instrument comprising two identical optical systems is then discussed. This uses two plates. Next is discussed a spectrograph containing two prism trains forming double reversed spectra, in which instrument only one plate is used and yet the necessity for changing the mechanical setting between exposures is avoided. —M. F. B.

Sensitizing the Photocell. Richard Fleischer. Electronics, February 1931, pages 518-519, 530.

A brief discussion of the alkali metals and the process of sensitizing by spark discharge.—M. F. B.

Prism Size and Orientation in Minimum-Deviation Refractometry. L. W. Tilton. Bureau of Standards Journal of Research. Vol. 6, No. 1, (1931), page 59.

An investigation of the optical error in the pointing of telescopes, and of variations therein with width of objective aperture, indicates that the effect of marginal aberration is often sufficiently deleterious to seriously impair the advantages which should result from the use of the larger apertures. The utility of larger prisms for more accurate index measurement is, therefore, subject to question. The experienced ratios of the probable error in pointing to the limit of angular resolution are, moreover, smaller than was expected for the narrower effective widths of telescope apertures and frequently they do not exceed 1/30. For sixth decimal place determinations of refractive index by minimum-deviation measurements when using a 60° prism, it is shown that a suitable and sufficient length of prism surface is approximately 2 cm, a constant value for all transparent media.

The Photometric Sensibility of the Eye and the Precision of Photometric Observations. E. M. Lowry. Journal of the Optical Society of American. Vol. 21, No. 2, (1931), page 132.

In this paper data are presented to show that for maximum photometric sensibility the brightness of the photometric field should be adjusted so that a brightness level of from 20 to 30 millilamberts is secured. At this brightness the difference fraction B/B has a value of 1.37 percent. Further the precision of photometric observations as expressed by the average percentage deviation, from the mean, of a single observation is 0.19 percent at the above mentioned optimum brightness level. At this same field brightness the maximum percentage deviation from the mean of a single observation was found to be 0.41 percent.

Formation of Photographic Images on Cathodes of Alkali Metal Photoelectric Cells. A. R. Olpin and G. R. Stilwell. Journal of the Optical Society of America. March 1931, pages 177-180.

A method of forming both negative and positive photographic images on the cathodes of potassium and sodium photoelectric cells in vacuum is described. These images are sharp and clear in every detail and can be permanently "fixed" by proper treatment. Among the materials which have been successfully used in treating the exposed surfaces to bring out these images are sulphur vapor, air, oxygen and hydrogen in the ratio of 9 to 1, hydrofluoric acid and bromine. During the time the image is forming, the photoelectric sensitivity of the illuminated portions decreases approximately 30 percent. After the image is fixed as a permanent record there is little difference between the sensitivity of the cathode area bearing the image and neighboring areas. Photographs of photoelectric cells are shown in which such photographic images are plainly visible.

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Foxboro Co.
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Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

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Brown Instrument Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

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Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

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Minneapolis-Honeywell Co.
Rubicon Company

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Foxboro Co.
Weston Elec. Inst. Corp.

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Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
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Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

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Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

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Illinois Testing Labs., Inc.
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Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
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Foxboro Co.
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Tagliabue Mfg. Co., C. J.
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Brown Instrument Co.
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Bristol Company
Brown Instrument Co.
Southwark Fdry. & Mach Co

Stroke
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Southwark Fdry. & Mach. Co.

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General Radio Company

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Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.

CURRENT REGULATORS

CYCLE COUNTERS
General Radio Co.

CYLINDERS-GRADUATED
Tagliabue Mfg. Co., C. J.

DECELEROMETER

DEFORMETER (Beggs)
Southwark Fdy. & Mach. Co.

DEMAND METERS

Gas
Foxboro Company

Electric
General Electric Co.

DENSITOMETERS

DENSOMETERS

DIVIDING HEAD

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Bausch & Lomb Optical Co.

DIVIDING MACHINES
R. Y. Ferner Co.
Gaertner Scientific Corp.

DRAFT GAGES—see Gages

DYNAMIC BALANCING EQUIPMENT
Alfred Suter

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Rawson Elec. Inst. Co.

EBULLIOMETERS
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ELECTRIC TELEMETER
Southwark Fdry. & Mach. Co.

ELECTRIC WAVE FILTER SECTIONS
General Radio Company

ELECTROMETERS
Rubicon Co.

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Southwark Fdry. & Mach. Co.
Alfred Suter

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Atlas Electric Devices Co.

FATIGUE TESTERS
Atlas Electric Devices Co.
Southwark Fdry. & Mach. Co.
Alfred Suter

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General Radio Co.
Leeds & Northrup Co.
Rubicon Company
Weston Electrical Inst. Corp.

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Taylor Instrument Cos.

FLOW METERS
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

FLUXMETERS
Leeds & Northrup Co.
Rawson Electrical Instr. Co

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FRACTIONAL HORSEPOWER MOTORS
Bodine Electric Co.

FREEZING CABINET
Atlas Electric Devices Co.

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Jewell Electric Instrument Co.
Leeds & Northrup Co.
Weston Elec. Inst. Corp.

Controlling
Leeds & Northrup Co.

Recording
Bristol Company
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Standards
General Radio Co.

FUEL ANALYSIS APPARATUS
Burgess-Parr Co.

FUEL FLOW INDICATOR

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Leeds & Northrup Co.
Taylor Instrument Cos.

FUSES
Instrument

GAGE RODS
Tagliabue Mfg. Co., C. J.

GAGE TESTING OUTFITS
Amthor Testing Inst. Co.

GAGES

Absolute Pressure
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Amplifying
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.

Comparator
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.

Cylinder
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.

Deformation
Southwark Fdry. & Mach. Co.

Depth
B. C. Ames Co.
Brown Instrument Co.
Federal Products Co.
Foxboro Company

Dial
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.

Differential Pressure
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

Draft
Amthor Testing Inst. Co.
Bristol Company
Brown Instrument Co.
Ellison Draft Gage Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Drill
Bausch & Lomb Optical Co.

Grinding
Federal Products Corp.

Liquid Level
Bristol Company
Brown Instrument Co.
Ellison Draft Gage Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Critical Frequency Measurements in Anomalous Trichromatic Vision. H. A. Blair, Journal of the Optical Society of America, November 1930, pages 601-615.

Critical frquency measurements for the light adapted anomalous trichromatic eye were made on spectra of 14 intensities. No Purkinje effect was observed. The Ferry-Porter law is apparently obeyed but the branches of the Porter graphs are more numerous than for normal vision. The results are interpreted by Allen's visual reflex theory. Critical frequency measurements at points from the fovea toward the temporal periphery for three wave lengths in the yellow fall on three distinct curves. The ends of the first two probably mark the boundary of the fovea and the macula lutea respectively. One peripheral normal curve is given.

X-RAYS, U-V RAYS, ETC.

The Optics of X-Rays. Arthur H. Compton. Journal of the Optical Society of America, February 1931, pages 75-89.

With this paper, Prof. Compton opened the symposium on the optics of the extremes of the spectrum at the Charlotteville meeting of the Optical Society of America. The immense range of the electromagnetic radiations is reviewed at the beginning of this masterly treatment, and the distinguished Chicago University physicist makes use of the interesting comparison that if we expand the scale of wave lengths so that the shortest known wave has a length equal to the thickness of a post card, the longest wave would on this scale extend from here to the nearest fixed star. He then reviews early studies of the properties of x-rays and the theories advanced before Laue's discovery of crystal diffraction establishing the wave characteristics of these rays. After a review of the well-known recent researches, the paper then discusses less familiar aspects of the application of the optics of x-rays. First and perhaps most important comes a summary of a recent elaboration of the methods of the Braggs, that has made possible a direct investigation of the arrangement of electrons in atoms, also studies of *the structure of molecules of gases* by means of diffraction patterns—which is very much like the measurement of the average diameter of water drops in atmospheric haze from the size of rings around the moon on certain nights. In the case of monatomic gases, the study of x-ray diffraction has revealed *the form of the atom itself!* One of the current problems of x-ray optics is the counting of the number of molecules in a cubic centimeter of a crystal, and this method is explained in mathematical detail. The statement is made that the straightforward application of optical methods to x-ray diffraction enables us to obtain our most reliable standard for x-ray wave length. Equally important are the current researches to determine one of nature's fundamental constants, namely the ratio of the charge to the mass of the electron. This appears to have slightly different values according to the method by which this constant is measured This is discussed in detail, including last year's work by Dr. Stauss in developing a precision method of determining x-ray refractive indices.—M. F. B.

The Optics of Radio Transmission. Ernest Merritt. Journal of the Optical Society of America, February 1931, pages 90-100.

Prof. Merritt's paper was presented by invitation at the 15th annual meeting of the Optical Society of America. A scholarly and interesting historical treatment dwelling especially on recent work and unsolved problems. No other optical phenomenon corresponds to the bending of Hertzian waves about the earth. (If there were such in the visible frequencies, we could guide light waves along wires in much the same manner that the carrier wave is guided in General Squire's "wired-wireless," and some of the problems of television would be greatly simplified). As the result of the combined work of amateurs, radio engineers, and physicists we now know that the range of practical radio communication is a minimum for wave lengths of about 200 m and that the range may be made greater either by increasing or by diminishing the length of the waves used. The only explanation offered for the long range reached by short radio waves is based upon ordinary optical principles, and the development of modern radio is proceeding by the application of the same methods that would be used in the case of visible light. The bending of short radio waves around the earth is explained as the result of refraction by ionized air. The greatest difficulty is that of determining how the electron density varies with the height above the earth. We must remember that ionized air causes absorption as well as refraction so that the medium between the two spherical mirrors is not perfectly transparent. The general belief that the ground wave is guided by the earth in much the same way that an AC is guided by a wire is doubtless correct for the immediate neighborhood of the sending station but evidence favors the view that at greater distances the ground wave also is chiefly an optical phenomenon. The chief optical problems, however, are related to the sky wave and are made difficult by our incomplete knowledge of conditions in the upper atmosphere—an excellent analogy being the problem offered by the shadow bands seen at the time of an eclipse. The problems in radio work involve not only refraction, reflection, absorption, interference and diffraction effects but also magnetic double refraction and a Faraday rotation of plane of polarization caused by the earth's magnetic field. The most puzzling problem is presented by "long" echoes—3 to 30 seconds—corresponding to distances of 500,000 to 5,000,000 miles.—M.F.B.

A Design of Metal X-Ray Tube. By N. S. Gingrich. The Review of Scientific Instruments, November 1930, pages 691-693.

This new tube consists essentially of one metal part connected to ground potential, one metal part connected to potentials up to 60 peak kv, and a pyrex glass tube for insulation. A fine piece of design and workmanship, judging from the illustrations. The focus can be varied in size from a pin point to the full size of the target face.—M. F. B.

Ultraviolet Spectrophotometry: Comments on Apparatus and Experimental Methods. George E. Davis & Charles Sheard. Journal of the Optical Society of America, January 1931, pages 47-58.

A simple and satisfactory type of container for the underwater spark, with suitable electrical circuits, and a new type of quartz cell to contain the liquids under examination, are described. Some points are presented concerning the use of the under-water spark and the methods of obtaining data with the quartz spectrograph and Hilger rotating sector photometer. Desirable modifications of the usual apparatus are suggested in order to increase the rapdity of the method and enhance its field of usefulness, particularly in the study of unstable solutions with varying transmissive properties.

Ultra-Sensitive Vacuum Tube. Electrician, Vol. 105, Nov. 7, 1930, page 554.

The General Electric Co. of N. Y. has developed a vacuum tube of extreme sensitiveness. Something like 3 trillion electrons/sec. flow through an ordinary 50-watt incandescent lamp: the new vacuum tube being capable of measuring accurately a flow of about 63 electrons/sec. One major application of the new tube will be laboratory measurement of currents in ionization chambers to indicate the intensities of x-ray and ultra-violet light beams.—W. H. B

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Pocket
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Illinois Testing Labs., Inc.
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Taylor Instrument Cos.

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Brown Instrument Co.
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Federal Products Corp.
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Foxboro Co.

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Brown Instrument Co.
Foxboro Co.

Wind
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Brown Instrument Co.
Taylor Instrument Companies

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General Radio Co.
Illinois Testing Labs., Inc.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
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Rubicon Company
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Electrical
Brown Instrument Co.
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GAS-METERS
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GASOMETERS

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Tagliabue Mfg. Co., C. J.

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Tagliabue Mfg. Co., C. J.

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Leeds & Northrup Co.
Rubicon Company
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GROUND-OHMER
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Rubicon Company
Weston Elec. Inst. Corp.

HIGH VOLTAGE

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Measuring Devices
General Electric Co.
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Testing Devices
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Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

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Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

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Leeds & Northrup Co.
Rubicon Company

Controlling, Recording
Leeds & Northrup Co.

HYDROMETERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

HYGROMETERS
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

IMPACT HARDNESS TESTER
Alfred Suter

IMPACT TESTING MACHINES
Alfred Suter

Alternating

INDICATORS—See Gages

INDUCTANCES
General Radio Co.
Leeds & Northrup Co.
Rubicon Company

INSTRUMENT CALIBRATION AND REPAIRS
Amthor Testing Inst. Co.
Jewell Electrical Instrument Co.
Rubicon Company
Weston Elec. Inst. Corp.

INSTRUMENT FUSES

INSTRUMENT OILS

INSTRUMENT TRANSFORMERS
General Electric Co.
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.

INSULATION TESTING EQUIPMENT
General Electric Co.
Leeds & Northrup Co.
Rubicon Company

INTEGRAPHS & INTEGRATORS
Leeds & Northrup Co.

INTERFEROMETERS
Gaertner Scientific Corp.

INVERTED CONVERTERS
Bodine Electric Co.

JOB TIMING RECORDERS

KEYS AND SWITCHES
General Radio Co.
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Foxboro Co.

KILOVOLT AMPERE METERS

KLYDONOGRAPHS

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Atlas Electric Devices Co.

LACTOMETERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

LAUNDER-OMETER
Atlas Electric Devices Co.

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Gaertner Scientific Corp.

LEVELS

Centering
Bausch & Lomb Optical Co.
R. Y. Ferner Co.

Engineer's, Wye, Precision, Prism
R. Y. Ferner Co.
Taylor Instrument Companies

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Buffalo Meter Co.

LOCOMOTIVE INDICATORS
Southwark Fdry. & Mach. Co.

LUSTER METERS

MACHINE OILS

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Rubicon Company

MANOMETERS
Brown Instrument Co.
Defender Automatic Regulator Co.
Foxboro Co.
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MASTER CLOCKS
Gaertner Scientific Corp.

MEGOHMMETERS
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Rubicon Company

MEGOHM VOLTMETERS
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.

MELTINGPOINT APPARATUS
Burgess-Parr Co.
Tagliabue Mfg. Co., C. J.

METER PROVERS, Gas

METER TESTERS, Gas

Rays of Slow Electrons and Their Technical Application (Strahlen langsamer Elektronen und ihre technische Anwendung). E. Brueche. Forschung und Technik, 1930, pages 23-46.

A short description of the elastic, magnetic, current and energy properties of the electron methods of producing well defined, slow moving electron-rays is given. It is possible by changing the gas concentration and by suitably shaping the anode to generate "thread-rays" of 1 mm. diameter; these rays are very well adapted for the measurement of magnetic fields, earth field, field components so that a practically useful airplane compass of this kind has already been developed. Further, this ray can be used for finding current-carrying cables, for increasing currents, high frequency meters, product and quotient measurements. Some practical electron-ray tubes are described and the principles of all measurements named above fully explained.—Ha.

Application of Refraction of Electrons (Ueber Anwendung der Elektronenbeugung). E. Rupp. Forschung und Technik, 1930, pages 18-22.

For testing the structure of materials, x-rays have taken a dominant position when the space lattice is to be determined. For determining the surface structure and lattice, electrons are used with much greater advantage because of the smaller degree to which they penetrate into the material Pictures can be made in a few seconds while exposures with x-rays require hours. The method uses electron velocities of 5000 volts and more. The tubes used and the practical application are described and some results of measurements of gas inclusions in metallic surfaces, chemical reactions of catalytic surfaces and glow-electrically and light-electrically acting surfaces. The results are illustrated by curves and diagrams.—Ha.

Current in X-Ray Tubes. L. G. H. Sarsfield. Electrical Review, Sept. 26, 1930, pages 487-488.

Describes method of compensating for the effect of capacity currents in measuring instruments. Opposition current is generated in a special grounded tertiary winding of a few turns on the x-ray transformer. The ends of this tertiary winding are brought out and connected to a condenser. By suitable adjustments, the current flowing in the special circuit is made equal in magnitude to the capacity current in the x-ray transformer. If the special circuit be connected so as to pass its current through the milliammeter in opposition to the capacity current due to the x-ray transformer, the true x-ray tube current will be indicated by the instrument.—M. S.

X-Ray Examination of Commercial Galvanized Iron by a Modified Reflection Method. Charles W. Stillwell and George L. Clark. Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 266-272.

A modified technic for obtaining diffraction patterns by reflection is described, the method being particularly suitable for metals and alloys. Ten references are cited.—M. E. H.

X-Ray Inspection of Castings and Forgings. Iron Age, February 19, 1931, pages 618-619.

Describes x-ray equipment for both radiographic and fluoroscopic examination of aluminum and steel castings used in airplane motors. The x-ray equipment was made by the Kelley-Knett Co. —V. S. P.

MICROSCOPY

A New Microscope Hot Stage. I. Amdur and E. V. Hjort. Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, page 259-260.

An easily constructed hot stage for use with the microscope in making melting point determinations of very small amounts of material, is described. Its range is room temperature up to 600°C. —M. E. H.

Microscopical Methods in Analytical Chemistry. Clyde W. Mason. Industrial & Engineering Chemistry, Anayltical Edition, July 15, 1930, pages 203-206.

Some of the many uses of the microscope in chemical analysis are presented. The analytical applications discussed here are considered 1) as aids or supplements to ordinary macroanalytical methods, both qualitative and quantitative, and 2) as a unique means of making qualitative and quantitative analyses.—M. E. H.

Some Recent Improvements in Metallographic Equipment. J. W. Morris. The Instrument World. February 1931, pages 229-231.

A thorough and well illustrated description of the new Leitz Metallographic Microscope, M. M., is given.—M. F. B.

Photomicrography with the 365mμ Mercury Arc Line. A. P. H. Trivelli and L. V. Foster. Journal of the Optical Society of America, February 1931, pages 124-131.

A joint communication from the research laboratories of the Eastman Kodak Company and from the scientific bureau of Bausch and Lomb Optical Company. Without doubt the highest resolution is secured by Kohler's ultra-violet photomicrographic outfit, but micrography with λ365 mμ approaching this resolution has the following advantages over Kohler's apparatus: (1) A glass system can be used instead of the expensive quartz system. (2) The light source is a mercury arc lamp with filters, which is much simpler than the spectroscopic outfit used to obtain a high intensity cadmium line. (3) The focusing can be greatly simplified. One of the author has overcome the difficulties previously experienced with commercial objectives. The arc spectrum of mercury in the near ultra-violet is discussed, as are light sources, objectives, immersion oils, microscopic objects, photographic materials and finally the results, which are illustrated by comparative photomicrograms.—M. F. B.

Microscopic Investigation of Metals. V. N. Krivobok. Proceedings of Engineers' Society of Western Pennsylvania, Vol. 47, February 1931, pages 45-62.

A non-technical review emphasizing the purposes of metallurgy, and the specific uses of metallography related thereto. With regard to inspection of metals and alloys, microscopic studies reveal the characteristics, the previous history of the sample and its suitability for a given purpose—but only when the sample is properly prepared by an experienced operator. This is illustrated by 7 microphotographs. The second phase of the metallographist's work is the inspection and investigation of material after a failure has occurred. Under the third category of work, the author discusses the development of new materials, and the illustrations show how to recognize definite changes in properties. The fourth function dealt with is true research or scientific metallography, under which 5 illustrations of martensite decomposition are discussed.—M. F. B.

PHOTOGRAPHY

Photographic Estimation of Foreign Materials in Gums and Resins. E. A. Georgi. (Hercules Experimental Station, Hercules Powder Co., Kenvil, N. J.) Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 331-334.

Photomicrographic method is applied to the estimation of dirt in gums, resins, etc.—M. E. H.

MICROMETERS
Amthor Testing Inst. Co.
R. Y. Ferner Co.
Gaertner Scientific Corp.

MICROAMMETERS
General Electric Co.
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Weston Electrical Inst. Corp.

MICROFARADMETERS
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rubicon Company
Weston Electrical Inst. Corp.

MICRO PYROMETERS

MICROSCOPES

Brinell
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Alfred Suter

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R. Y. Ferner Co.

Metallographic
Bausch & Lomb Optical Co.

Petrographical
Bausch & Lomb Optical Co.

Toolmakers'
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.

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MILLIAMMETERS
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Weston Electrical Inst. Corp.

CHEMICAL ANALYSIS & APPARATUS

Apparatus for the Determination Aboard Ship of the Salinity of Sea Water by the Electrical Conductivity Method. F. Wenner, E. H. Smith & F. M. Saule. Bureau of Standards Journal of Research, Sept. 1930, pages 711-734.

The apparatus described furnishes a convenient means for the determination of the salinity of samples of sea water as they may be collected. It consists essentially of a Wheatstone bridge, conductivity cells of a type which may be filled and emptied during fairly rough weather, and the necessary auxiliary equipment, all built into a single cabinet. A special feature is the use of two similar conductivity cells in adjacent arms of the bridge. When both are filled with samples of sea water, even though not of the same salinity, both have very nearly the same temperature coefficient, so the balance of the bridge is not greatly affected by small uncertainties of the temperature. Further, the complicated actions taking place at the electrodes, generally referred to as polarization, are substantially the same in both cells, so the effects of polarization are largely neutralized.

New Criterion for Coking Value of Coal. T. C. Lloyd, Chemical & Metallurgical Engineering, March 1930, pages 169-171.

Presents some results of a study of the plastic range of coal by the gas flow method. Describes apparatus used.—M. S.

Automatically Controlling Acid Effluents. H. K. Richardson, Chemical & Metallurgical Engineering, May 1930, pages 293-295.

Description of the methods and instruments used for automatically neutralizing and wastes at the Bloomfield, N. J., Plant of the Westinghouse Lamp Co. Electrolytic conductivity and hydrogen-ion recorders with automatic controls, and flow meters are used.—M. S.

Improved Water-Purity Meter. Electrical Review, Nov. 28, 1930, page 931.

Description of the "Dionic" meter developed by Evershed & Vignoles, Ltd., which gives a continuous record. It measures the conductivity of water or other dilute solutions between two electrodes. It is fed from the mains or a battery. Automatic compensation for variation in temperature of the water is provided in the form of a plunger which moves up and down in the tube, providing the measured path. The plunger is operated by a bi-metallic strip immersed in the solution under test.—M. S.

Correct Method of Analyzing for Carbon in Rustless Steels. C. M. Johnson, Iron Age, February 12 1931, pages 549-551.

Increased use of high-Cr and high-Ni steels of very small C content does not permit of an analytical tolerance of 0.01% C in determination of this element. One cause of error in C work is the introduction of S above 0.05% to as high as 0.75% S. Describes method and apparatus used for obtaining accurate analysis of both low and high-S types. Tabulates results of test.—V. S. P.

An Improved Apparatus and Method for the Analysis of Gas Mixtures by Combustion and Absorption. Martin Shepherd. Bureau of Standards, Vol. 6, No. 1 (1931), page 121.

This paper describes an improved volumetric apparatus for the analysis of gases by combustion and absorption methods. The apparatus is of the type which has a series of pipettes connected to the burette and is commonly called an "Orsat." The operating technique is given in a set of simple instructions. While the unit is similar to many commercial forms of gas analysis apparatus, it differs in a number of details of the assembly and the construction of individual parts. The adjustment and control of pressure balances have been greatly improved. Distinct advances have been made in the designs of the combustion and absorption pipettes, and of the manometer-compensator unit. A new type of mounting permits the easy removal and replacement of any part. The unit as a whole has been made as modern as possible. It has been found more satisfactory, both as to accuracy obtainable and ease of manipulation, than other available models.

Transference Phenomena and the Existence of Complex Ions as Interpreted by Their Magneto-Chemical Behavior. Simon Freed and Charles Kasper. Journal American Chemical Society, July 1930, pages 2632-2638.

A new modification of the Gouy method is described which permits the measurement of relative susceptibilities to be made easily and accurately. See also pages 2702-2712, same Journal.—M.E.H

A Convenient Form of Gas Combustion Pipet. Note by E. W. R. Steacie, Journal American Chemical Society, July 1930, page 2811.

With this form of pipet, danger of leakage is avoided, the time for a combustion is materially shortened, and the volume range is increased. It can also be used as an explosion pipet.—M. E. H.

True Boiling Crude Analysis. G. A. Beiswenger and Wm. C. Child (Technical Service Division, Standard Oil Company of New Jersey). Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 284-287.

Presented before the Division of Petroleum Chemistry at the Atlanta Meeting of the American Chemical Society, April 1930. An improved method for the determination of the quantity and quality of products obtainable from a petroleum crude oil is presented. The procedure consists in distilling the sample in a true-boiling-point still, followed by correct blending and inspecting. The still is described and diagram given.—M. E. H.

Phosphoric Acid for Determination of Melting Points. Foster Dee Snell. Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, page 287.

Sirupy phosphoric acid is used between 100 and 300 degrees C. in an open vessel. The acid loses water at about 100 degr., and the vapor produced creates circulation.—M. E. H.

Special Hydrometer for Aqua Ammonia. D. F. Farrar (Read Phosphate Co., Nashville, Tenn.). Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, page 293.

The aqua ammonia hydrometer is graduated in per cent ammonia ranging from 18 to 28%, with 0.25% sub-divisions. It is destined mainly for use in fertilizer factories where the strength of ammonia is about 25% as made from the anhydrous. Direct reading of the scale is correct for 60 degr. F., but for other temperatures correction must be made according to chart which is given in the article.—M. E. H.

Application of the Falling Cylinder to the Measurement of the Viscosity of Thick Rubber Cements. W. F. Busse and W. B. Doggett (The B. F. Goodrich Co., Akron, Ohio). Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 314-319.

Presented before the Division of Rubber Chemistry at the Atlanta Meeting of the American Chemical Society, April 1930. Falling-cylinder viscometers using steel cylinders were designed for use in control testing, and simplified equations were developed for their use. These have been applied even for thick cements and asphalts, and should be useful in studying other materials. —M. E. H.

Determination of Perchlorate. H. H. Willard and J. J. Thompson. Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 272-273.

An apparatus designed for determining small quantities, 0.03-0.4 gram sample, of perchlorate. Diagram is given.—M. E. H.

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Burgess-Parr Co.

Providing for Changes of Temperatures in Volumetric Analysis. W. G. Mellon. Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 260-263.

Charts are shown to provide for applying either calibration or temperature correction separately or combined to volumetric apparatus.—M. E. H.

Spectroscopic Detection of Fluorine. Jacob Papish, L. E. Hoag, and W. E. Snee. Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 263-264.

An indirect spectroscopic method for the detection of fluorine in small quantities is described. It consists in subjecting a mixture of a fluoriferous substance with a calcium salt to arc excitation and examining the spectrum for bands of fluoride of calcium. It is visible when 0.01 mg. of fluoride is present in the zone of excitation.—M. E. H.

The Baro-Buret. II-Application to Gas Evolution Methods of Analysis. Harold Simmons Booth and Newton C. Jones. Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 237-240.

The application of the baro-buret to gas evolution methods of analysis is described. Data are given to show that the baro-buret, when careful attention is given to errors and their corrections, gives both rapid and accurate results in quantitative analysis. A partial list of determinations possible by this method is included. 17 references.—M. E. H.

Apparatus for the Determination of Ignition Temperature of Powder Substances. Paul W. Edwards and Roger W. Harrison (Bureau of Chemistry and Soils, Washington, D. C.) Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 344-345.

Description and diagram of an apparatus for determining the ignition temperature of dusts in static condition.—M. E. H.

The Use of Calcium Hydride for the Determination of the Solubility of Water in Benzene, Carbon Tetrachloride and Toluene. Chester K. Rosenbaum and James H. Walton. Journal American Chemical Society, Sept. 1930, pages 3568-3573.

A new improved apparatus and method have been developed for the gasometric determination of water in certain organic solvents.—M. E. H.

The Removal of Gases from Liquids. Roger K. Taylor. Journal American Chemical Society, Sept. 1930, pages 3576-3578.

Description is given of apparatus and method for removal of gases from appreciably volatile liquids, and of apparatus and method for pumping off, measuring and analyzing small amounts of gas, in absence or presence of condensable vapors.—M. E. H.

Motor-Fuel Volatility. Industrial & Engineering Chemistry, June 1930. Part I of this series of papers appears in the March 1930 number of Industrial & Engineering Chemistry. Part II Starting Volatility. George Granger Brown, Charles L. Nickols and Paul Bigby. Pages 649-653. Part III—Effective Volatility under Driving Conditions. Jarvis E. Miller and George Granger Brown. Pages 653-662. Part IV—Relation between Atmospheric Temperature, Fuel Volatility, and Engine Performance. Charles L. Nickols and George Granger Brown. Pages 662-672. Part V—Vapor Pressure and Vapor Lock. E. A. Clarke, Hal B. Coats and George Granger Brown. Pages 672-682.

The second paper (Part II) relates equilibrium volatility to ease of starting as determined by actual engine tests. Part III defines effective volatility under driving conditions and indicates how it may be determined from the equilibrium volatility or A. S. T. M. distillation data. Part IV relates effective volatility to engine performance and suggests the A. S. T. M. distillation characteristics required for satisfactory performance under different conditions of atmospheric temperature. Part V discusses the relation of vapor pressures to vapor lock and suggests the fuel characteristics requisite to insure freedom from this trouble. Apparatus and measuring devices used in the various tests are described and many performance curves given. 17 references.—M. E. H.

The Surface Tension of Aqueous Solutions of Para-Toluidine. David M. Gans and William D. Harkins. Journal American Chemical Society, June 1930, pages 2289-2295.

A slightly improved procedure for the determination of surface tension by the drop weight method is presented. Diagram is shown.—M. E. H.

Applications of the Photo-Electric Cell to Chemical Analysis and Control. H. W. Partridge. Industrial & Engineering Chemistry Analytical Edition, July 15, 1930, pages 207-213.

Herein given briefly the history of methods based upon photo-electric properties, applications of the methods to the arts and industry, methods of measurement with and without amplification, specific chemical applications, some remarks as to selection of apparatus and limitations. 168 references.—M. E. H.

Potentiometric Titrations. A Review and a Report of Progress. N. Howell Furman. Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 213-224.

The author reviews the outstanding recent trends in the development of the methods of potentiometric titration, as follows: 1) proof that the method is capable of great precision; 2) simplification of the experimental technique (bimetallic electrodes); 3) development of continuous-reading methods; 4) beginnings of the study of potentiometric micro-titration; 5) notable progress in the study of all types of reactions; and 6) the opening up of new fields of study in solvents other than water. Classified and alphabetical bibliographic of potentiometric methods of titration are included. 227 references.—M. E. H.

Electrode Potentials in Analytical Chemistry. Stephen Popoff. Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 230-232.

The theory and practice involving electrode potentials in anayltical chemistry are given, using as examples electro-analysis and the hydrogen, glass, oxygen, and other electrodes. The electrodes involving other oxidation and reduction reactions are also discussed from the standpoint of the necessity of dealing only with galvanic cells in which the reactions are easily and completely reversible, and in the light of recent advances in the theory and practice of electromotive force measurements. 18 references are cited.—M. E. H.

Conductometric Titrations. I. M. Kolthoff. Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 225-230.

In practical analyses conductometric titration methods should be much more applied than is the case now. In water analysis, in the determination of the alkalinity and ash of sugars, acidity of lemonades, fruit juices, wine, beer, oils and fats, lacquers, etc., the conductometric method will render valuable information. The method will be of great aid in the determination of peptizing in a colloidal solution though the interpretation of the experimental curves is somewhat obscured on account of the adsorbent properties of the flocculate formed during the titration. The author reviews the most important applications of the method, and emphasizes that in many cases where ordinary or potentiometric methods fail to give results a conductometric titration can often be successfully used.—M. E. H.

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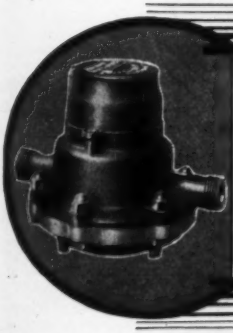

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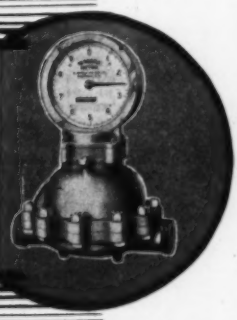

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CHEMICAL ANALYSIS AND APPARATUS

The Dissociation of Carbon Dioxide in the Electrodeless Discharge. Herschel Hunt and Walter C. Schumb. Journal American Chemical Society, Aug. 1930, pages 3152-3159.

An apparatus suitable for producing a high frequency oscillatory electrodeless discharge is described.—M. E. H.

Applicability of the Quinhydrone Electrode to Unsaturated Acids. W. H. Hatcher and M. G. Sturrock. Journal American Chemical Society, Aug. 1930, pages 3233-3235.

It is shown that the quinhydrone electrode is not applicable when the tendency of the solution to reduce is such that the ratio of hydroquinone to quinone is seriously altered.—M. E. H.

Industrial Analysis and Recording of Carbon Dioxide and Oxygen in Air. William F. Hamilton (Charles Engelhard, Inc., Newark, N. J.). Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 233-237.

An apparatus is described for the continuous indicating and recording of the percentage of carbon dioxide and oxygen in air. The method is based upon measurement of the relative thermal conductivities of gases, using quartz-protected platinum spirals as heating and temperature measuring elements. An improved thermal-conducitivity gas analysis unit is also described and discussed. The effect of varying gas composition temperature, current, and flow rate is shown. The time lag is shown to be constant and independent of the magnitude of change of gas composition, providing a constant flow rate is maintained. 13 references.—M. E. H.

Apparatus for Micro-Catalytic Hydrogenation. J. F. Hyde and H. W. Scherp. Journal American Chemical Society, Aug. 1930, pages 3359-3363.

An apparatus for the measurement of small quantities of gas absorbed or evolved in a chemical reaction is described. It is particularly adapted to catalytic hydrogenation on a micro-scale, in which case an accuracy of $\pm 2\%$ has been obtained under the conditions described.—M. E. H.

VISCOSITY

Classifying Transmission and Rear-Axle Lubricants. C. M. Larson. S. A. E. Journal, March 1931, pages 321-331.

Transmission and rear-axle lubricants frequently have small quantities of soap or other material added to decrease the tendency of the lubricant to leak from the housings. Although these additions may increase the apparent viscosity of the oil, they may have little or no effect on the load-carrying properties at high temperatures or the tendency of the lubricant to channel or to make gear-shifting harder at low temperatures than with the straight oil. The investigation reported in this paper covers the determination of Saybolt viscosities from -20 to $+210$°F. and constitutes a classification in terms of viscosity, low temperature consistency, channel effect and drag resistance to shifting at low temperatures as well as non-leak and film strength at high temperatures. "The Saybolt Furol instrument is of little value in determining viscosities at low temperature, and pour-test data of no practical value in deciding whether a lubricant will function properly at low temperatures . . . The most accurate and satisfactory method of determining the viscosity of gear lubricants at any temperature from -20 to $+100$°F. is by no means of the pressure viscosimeter." On account of the many different conditions under which transmission and rear-axle lubricants are used and because of the many different methods of manufacture, no one detailed specification is applicable as an indication of the performance characteristics of a lubricant. Therefore, the author asserts, consumers must necessarily depend upon the individual oil companies to produce a quality lubricant, using for their guidance a viscosity, consistency and film-strength classification to be determined upon and subsequently published in the car manufacturers' instruction books. Among the special instruments described in detail are the Sinclair Refining Co. pressure viscosimenters, the Knopf viscidometer for making the spike test, a device for making sleeve tests, another device for making transmission gearshift tests, and an apparatus for testing lubricating-film strength. —M. F. B.

The Standardization of a Modified Ostwald Viscometer. H. M. Chadwell and B. Asnes. Journal American Chemical Society, Sept. 1930, pages 3493-3507.

Three viscometers of the Ostwald type as modified by Washburn and Williams have been constructed similar to each other with the exception of the configuration of the ends of the capillaries, which varied from gradual trumpets to squarely fractured ends. The dimensions of these viscometers were determined as accurately as possible. The times of flow with water were determined at different temperatures. It was found that any of the three tubes reproduced the Bureau of Standards data for water on the assumption that the factor m is zero, and was independent of the configuration of the capillary ends.—M. E. H.

A Method for Determining the Viscosity of Corrosive Gases and the Molecular Diameter of Nitrogen Pentoxide. Henry Eyring and G. A. Van Valkenburgh. Journal American Chemical Society, July 1930, pages 2619-2624.

An experimental arrangement for measuring the viscosity of corrosive gases is described. It is made entirely of pyrex and has no stopcocks. Diagram is given.—M. E. H.

Wetting of Pigments and Other Powders. William D. Harkins and Roy Dahlstrom. Industrial & Engineering Chemistry, Aug. 1930, pages 897-902.

Presented before the Division of Paint and Varnish Chemistry at the Atlanta Meeting of the American Chemical Society, Apr. 1930. A method has been developed by means of which the total energy of immersion of a powder with a clean surface can be obtained. Calorimeter and film balance for measurements of insoluble films on water and for measurement of area per molecule in film, are described.—M. E. H.

The Adhesion-Tension Cell in Paint Investigations. Elliott L. McMillen (New Jersey Zinc Co., Palmerton, Pa.) Industrial & Engineering Chemistry, Aug. 1930, pages 890-893.

Presented before the Division of Paint and Varnish Chemistry at the Atlanta Meeting of the American Chemical Society, Apr. 1930. The factors influencing the accuracy of wettability measurements upon lithopone by means of the Bartell-Osterhof cell have been investigated. The wettability data indicate that poor wettability is not the cause of plasticity of solid-liquid systems. —M. E. H.

Standard Methods (Revised) for Determining Viscosity and Jelly Strength of Glue. National Association of Glue Manufacturers, Committee: F. L. DeBeaukelaer, J. R. Powell, E. F. Bahlmann; M. L. Sheely, Chairman of Revision Committee (1930). Industrial & Engineering Chemistry, Analytical Edition, July 15, 1930, pages 348-351.

The standard viscosity pipet and the Bloom gelometer are described and diagrams given, with detailed specifications of methods and equipment.—M. E. H.

ASTRONOMY, GEODESY, GEOLOGY, ETC.

A Description of the 36-Inch Aperture Telescope for the Royal Observatory, Edinburgh. C. Young. Transactions Optical Society, 1929-30, No. 4, pages 229-232.

This is the largest reflector in Great Britain. Designed and constructed by Messrs. Sir Howard Grubb, Parsons & Co., at the Optical Works, Newcastle-on-Tyne, in collaboration with Professor R. A. Sampson, F. R. S., the Director of the Observatory. It is of the Cassegrain form and is to be used chiefly for spectrographic observations, but is also adaptable for other purposes.—M. F. B.

Oil Well Surveying with the Gyroscope. Editorial article. The Sperryscope, Vol. 6, No. 4, pages 1-2.

Reasons are given why the oil well driller should know as soon as possible (1) if his drill starts on deflected path from the vertical, and (2) exactly the geographical relation of any part of the hole to its mouth. The Surwell Clinograph combines a gyroscope, film camera, timing device, batteries, etc. in a protective housing which is lowered into the well. Gyroscope holds axis of rotation in the north-south position regardless of cable twist and automatic camera provides records a few seconds apart showing direction, slant and time.—M. F. B.

AVIATION, AVIGATION, NAVIGATION

Determining Orbits of Moving Objects in Space by Means of Cinematographically Recording Theodolites (Die Vermessung der Flugbahn bewegter Ziele im Raum mittels kinematographisch registvierender Theodolite). R. Leonhardt. Die Messtechnik Vol. 7, No. 1, Jan. 1931, pages 7-11.

New construction of theodolite permits determining the orbit of a moving object in space by determining the locations of the object in sufficiently short time intervals, even for very narrow curves. In this way air-currents and other meteorological phenomena can be studied by following the course of pilot balloons, but the method is especially useful for the determination of absolute velocity, manoeuverability and starting and landing characteristics of airplanes. The described theodolite records on a moving film the field of vision together with the azimuth angle and a clock dial from which the location of the object is fixed, and the whole curve or orbit can be evaluated from a number of such individual locations. The instrument is built by the Askania-Werke, Berlin-Friedman.—Ha.

Cinema-theodolites (Kino theodolite). E. Roux. Zsch. Feinmechanik und Praezision vol. 38, No. 24, Dec. 31, 1930, pages 1-2.

These instruments serve for the observation of pilot-balloons for meteorological purposes and have to measure 1) the velocity in space independent of air movement; 2) the exact location of aeroplanes at definite times under correction of errors by the observer; 3) to reproduce airplanes in their positions; 4) make possible dynamic investigation of behavior of planes during normal flights; 5) investigation of turbulence over different terrain formations. The means to solve these problems satisfactorily and the optical arrangement of such an instrument are described. The instrument is built by the Askania Werke, Berlin.—Ha.

CALCULATION

Calculation of Ohmic Resistances for Alternating Current (Calcul des résistances ohmiques en courant alternatif) Marcel Mathieu. L'Industrie Électrique, Aug. 10, 1930, pages 341-344.

Describes slide-rule used in solving the formulas proposed by Albert Levasseur.—M. S.

MEASUREMENT, GENERAL (INCL. LABORATORIES)

The Research Laboratory of the AEG (Das Forschungsinstitut der AEG). C. Ramsauer. AEG-Mitteilungen, No. 2, Feb. 1931, pages 48-55.

Describes aims and organization, buildings, and equipment. There are four groups of research: scientific research, technical research and development, manufacturing development, and research for other departments. The whole field of physics, theoretical and applied, is covered. —Ha.

Short-Cuts in the Rubber Laboratory. H. A. Depew (The New Jersey Zinc Co.) India Rubber World, Vol. 83, December 1, 1930, pages 59-60.

The article deals with the methods of obtaining stress-strain data on rubber compounds, in particular with the graphical methods of averaging stress-strain data.—G. N.

A Laboratory Line-Up for Vacuum Cleaners. D. G. Smellie. Product Engineering, November 1930, pages 521-523.

Describes laboratory, drafting room and experimental shop facilities of the Hoover Company. Instruments are listed, with purposes as regards testing vacuum cleaners and parts thereof, both in process of development and as finished products.—M. F. B.

Modern Rubber Laboratory Serves English Trade. The Rubber Age, February 10, 1931, pages 457-459.

Description of the first laboratory of its kind operated in England by any producer of rubber chemicals (Graesser-Monsanto Chemical Works, Ltd.) Eight illustrations.—M. F. B.

European Laboratories for the Testing of Materials. Franklin L. Everett. Mechanical Engineering, March 1931, pages 201-204.

Observations covering the more important British and continental university and industrial laboratories devoted principally to research in the mechanics of materials. 6 figs.—M. F. B.

INSTRUMENT DESIGN & CONSTRUCTION

The Determination of the Load-Curve of an Inclined Beam for a Uniform Division of the Scale (Die Ernnttelung der Last Kurve sienes Neigungs. viegeballkous fur gleichuassige Skalenenteilung). Karl Diehl. Die Messtechnik Vol. 7, No. 1, Jan. 1931, pages 3-7.

Balances with inclined beams have in recent years found wide application in industry and commerce for small as well as for heavy loads due to their entirely automatic and quick operation. The point of support and the point of load attack lie both on a curve. The theory for the determination of these curves and to make the latter as close as possible to a circle is discussed and illustrated on an example. The book review of the book of the same author may be referred to.—Ha.

Remote Transmission of Measurements (ICE Fernübertragnug von Messwerten). Die Messtechnik, Vol. 7, No. 2, Feb. 1931 page 56.

Description of an electrical arrangement which transmits the indications of manometers, steam meters, etc. to remote places. The pointer moves a sliding contact over a resistance. The instrument is built by Z. C. Eckardt, Stuttgart.—Ha.

New Portable Service Measuring Instruments (Neue tragbare Betriebsmessgeräte) P. M. Pflier and P. Wiessner. Siemens-Zeitschrift, vol. 11, No. 2, Feb. 1931, pages 56-64.

Cases formerly made of wood are now made of an insulating pressed material. Several of these new constructions are illustrated and a few improvements described.—Ha.

INDEX CARD SECTION

A file card index will be a valuable asset. It is suggested that this index information be cut out, mounted on cards, and filed in your desk or in a file box on top of your desk. You will then have within easy reach an index of instrument information of incalculable value.

SPEED AND ACCELERATION MEASUREMENT. M. F. BÊHAR. INSTRUMENTS, Vol. 4, No. 11, November, 1931, pages 581-606, 32 figs.

Continuation of Chap. XV of Handbook of Industrial Instruments. This instalment covers:
Section 22. Stroboscopes
26. Automatic Speed Control

MEASUREMENT OF AIR FLOW. E. OWER. INSTRUMENTS, Vol. 4, No. 11, November 1931, pages 607-617, 6 figs.

Chap. IX. (cont'd). This chapter is devoted to the various forms of manometers.

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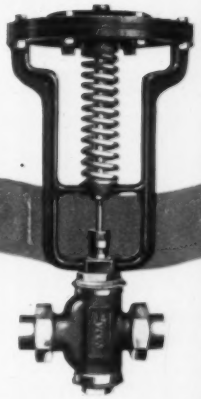

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